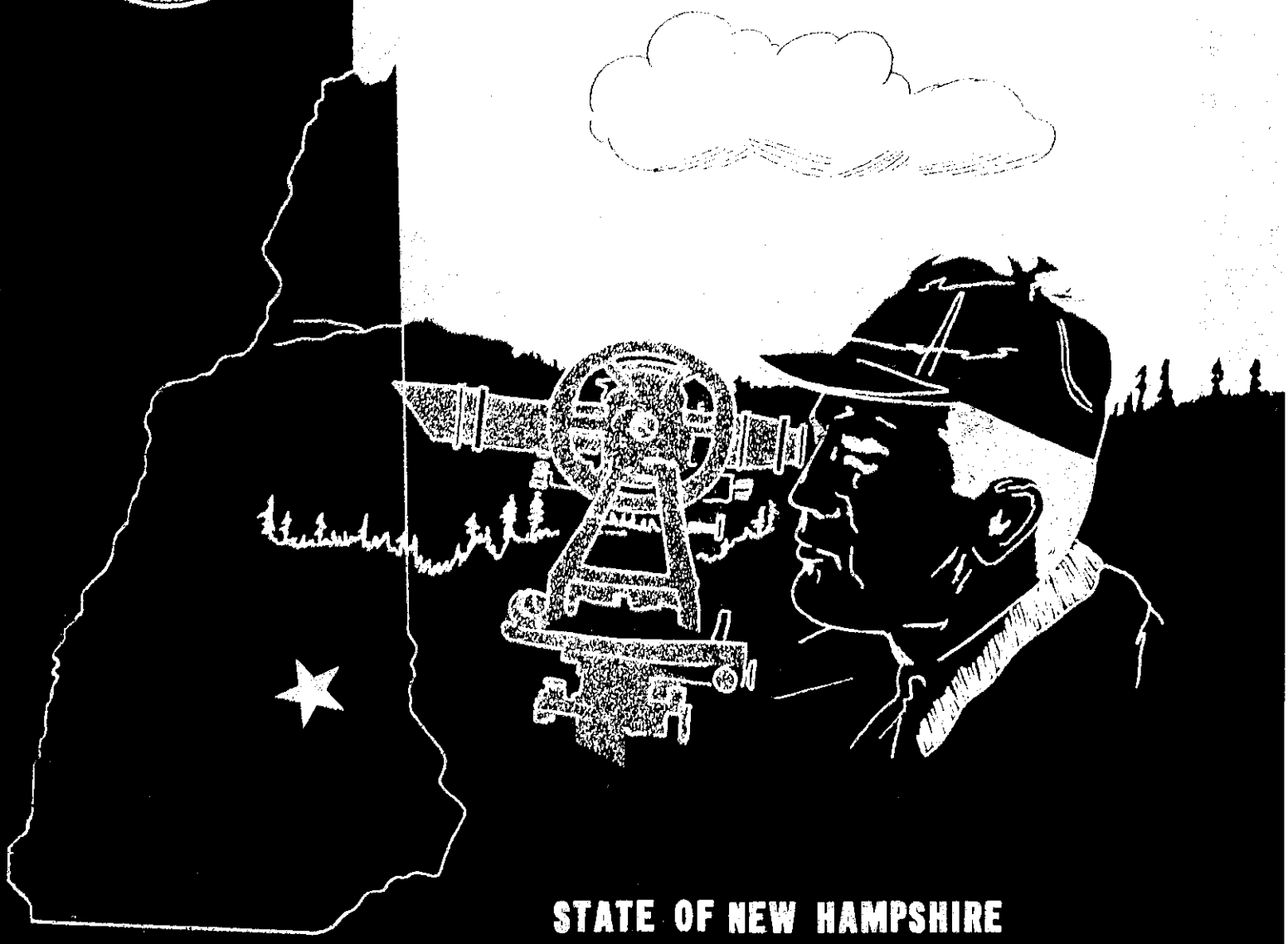
SURVEY MANUAL



STATE OF NEW HAMPSHIRE

DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

FOREWORD

The purpose of this manual is to outline policies and procedures adopted by the New Hampshire Department of Public Works and Highways that will serve as a guide for those performing duties related to survey work for the Department. Hopefully, this will result in a standardization of survey methods.

It is not intended that the publication of this manual will in any way preclude departures from the suggested methods on occasions where individual initiative could provide other acceptable methods that would be more practical and economical.

This manual is subject to continual change and updating. Such changes will be distributed as they are made.

JULY, 1972

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GENERAL INFORMATION

SECTION I

INDEX

110 ORGANIZATION OF SURVEY PARTY

The regular survey party consists of four (4) men: a Chief of Party, classification of Engineering Technician III or IV; a Transitman, classification of Engineering Technician II; a Chainman-Transitman, classification of Engineering Technician I, or a Chainman, classification of Engineering Aide II; and a Rodman, classification of Engineering Aide I. During the summer months a summer employee (college student, etc.) may be utilized to the degree of his ability as the fifth man, where needed, in the survey party.

111 DUTIES OF THE SURVEY PARTY PERSONNEL

The Chief of Party shall be held responsible for the activities, actions and remarks of his men in the field. He shall instruct them in the proper performance of their duties. He shall insist that they cultivate the habit of doing the field work expeditiously as well as accurately. He shall direct the attention of his superiors to individuals who have extraordinary ability and diligence as well as to those who are not responsive or show little aptitude for survey work. Any man who is guilty of negligence, disobedience, or gross misconduct shall be immediately reported to the Survey Supervisor who will take the appropriate action. The Party Chief's first allegiance can only be toward the best interest of the Department, and not toward his subordinates, which in the final analysis will be most beneficial to everyone involved. It is vital that he be prompt in submitting the various administrative reports covered elsewhere in this manual.

The Instrumentman must be able to use, adjust, and care for any precision instrument used by him. He should be taught to keep notes and take charge of the party during the absence of the Chief of Party.

A Chainman-Transitman's basic duties are those of the Chainman and in the absence of the Transitman, or on other occasions, he assumes the duties of the Transitman. He is considered a Transitman-in-Training.

A Chainman must be able to chain, use a locke level, be responsible for all "chain" and "rod" work done in conjunction with the Rodman. He should be taught, whenever the opportunity presents itself, the duties of the Transitman.

The Rodman performs all duties assigned to him by the Chief of Party which are laborious in nature; i.e., cutting brush and small trees, carrying supplies to and from the project and vehicle, handling level rod, assisting in chaining, etc.

As indicated above, each member of the crew should learn the duties of the position above his, in the interest of the Department as well as his own.

In order to have a survey party perform its work efficiently every member must willingly avail himself, whenever it doesn't conflict with his basic duties, to accomplish the many menial tasks involved in preliminary surveys.

120 # SURVEY EQUIPMENT AND SUPPLIES

NONEXPENDABLE	EXPENDABLE
AXES, 2¼ lb. - 3 lb.	ADJUSTERS, PLUMB BOB
BAG, STAKE, CANVAS	BATTERY, 1½ VOLT, THEOD., & FLASHLIGHT
BALANCES, SPRING	BATTERY, 9 VOLT, WALKIE TALKIE
BOB, PLUMB	BATTERY, 12 VOLT, FATHOMETER
BOOTS, RUBBER	BINDERS, FIELD BOOK
BOOK, FIELD AND LOOSELEAF	BLADE, BOW SAW
CASE, CLOTH TAPE	CHAIN, PLUMP BOB
CHAIN, STEEL, CANYON, 100, 200, 300 ft.	CRAYON, LUMBER, BLUE, RED, YELLOW
CHAIN, STEEL, DRAG, 50, 100 ft.	FILE, BASTARD 10"
CHISEL, ICE	FIRST-AID, SUPPLIES
COMPASS W/STAFF	FLAG, FLORESCENT W/STAFF
CONE, TRAFFIC, PLASTIC	FLAG, CLOTH, RED, DANGER
FRAME, SIGN HOLDER, METAL	HANDLE, AXE
GLASS, MAGNIFYING	HANDLE, BRUSH HOOKS
GRIPPER, STEEL TAPE	HANDLE, SLEDGE HAMMER
HAMMER, SLEDGE	MARKER, DRI-MARK
HELMET, ALUMINUM	MARKER, PIT, PLYWOOD
HOOK, BRUSH	NAILS, ALL SIZES
JUG, WATER, THERMOS	PAPER, FILLERS, FIELD BOOK
KIT, FIRST-AID	POINTS, PLUMB BOB
LEVEL, RT. ANGLE	RIBBON, CLOTH, RED
LEVEL, LOCKE	RIBBON, PLASTIC, IN COLORS
LEVEL, W/TRIPOD DUMPY OR "Y"	SPIGOT, THERMOS JUG
MACHETE, W/CASE	STAKES, GRADE, SOFTWOOD
MANUAL, SURVEY	STAKES, HUB, HARDWOOD
PIN, ADJUSTING TRANSIT	STRING, PLUMB BOB
PIN, FROST	TAPES, CLOTH 50ft. - 100ft.
PUNCH, STEEL	TARGETS, BRIDGE, WOOD
REEL, TARGET, GAMMON	
ROD, LEVEL	SPECIAL EQUIPMENT:
ROD, RANGE	BOAT, ROW
RULE, FOLDING, 6 ft.	CAMERA, POLAROID
SAW, BOW	DRILL, STAR
SCALE, ENGINEERS	GEODIMETER AND ACCESSORIES
SHEATH, PLUMB BOB	HAMMER, 3-LB.
SHOES, SNOW	JACKETS, LIFE
SHOVEL, SNOW	LEVEL, AUTOMATIC
SIGN, "MEN WORKING IN ROAD" METAL	RADIO, WALKIE-TALKIE
TABLES, IVES & KISSAM	ROD, LEVEL, FIBERGLASS 25'
TABLES, SPIRAL (BARNETT)	ROPE, NYLON AND HEMP
THERMOMETER	TARGET, ROD
TRANSIT, W/TRIPOD	
VEST, SAFETY	

120.1

FIRST-AID SUPPLIES

DESCRIPTION	UNIT
ACID, TANNIC	PKG.
AMPULES, AMMONIA	PKG.
BANDAGE, COMPRESS (2" x 2")	PKG.
BANDAGE, COMPRESS (4")	PKG.
BANDAGE, GAUZE (2" x 6 YD.)	PKG.
BANDAGE, TRIANGULAR	PKG.
BANDAIDS	PKG.
DRESSING, EYE	PKG.
GAUZE, ABSORBENT	PKG.
KIT, FIRST-AID (CASES ONLY 10 UNITS)	EACH
KIT, FIRST-AID (CASES ONLY 16 UNITS)	EACH
METAPHEN	PKG.
PADS, GAUZE (3" x 3")	PKG.
RHUS-LO CREAM (POISON IVY)	TUBE
SWABS, IODINE	PKG.
TOURNIQUET	EACH

121 PLASTIC TAPE COLOR CODE

Various colors of one (1) inch plastic tape, conspicuously attached to reference risers will be used to readily distinguish the character of alignment or control point to which it refers.

The following color code will govern:

RED	-	Center line or side stake.
BLUE	-	Ramp center line and ramp side stake.
WHITE	-	Ramp center line and ramp side stake.

COMBINATION OF COLORS

RED & YELLOW	-	Center line control points and ties.
BLUE & YELLOW	-	Ramp control points and ties.
WHITE & YELLOW	-	Ramp control points and ties.
GREEN & WHITE	-	Right of Way lines and bound points.

Fluorescent orange will be used by the Construction Division to identify clearing markers. Survey will not be supplied with this color.

125 PUBLIC RELATIONS

Before beginning a detailed study of the duties of a survey party, it will be well to consider the proper relation between the survey party and the general public. Surveyors of this Department, even though they may hold subordinate positions, are employees of the State and are in reality employees of every taxpayer of the State, who observes the

conduct of State employees whether on or off duty. Citizens like to know what is going on, and in the course of a field survey many questions are asked by them. The Department insists that these questions shall be answered courteously. Subordinates should politely refer all questions to the Chief of Party who will explain, within reason, the objectives of the work. Courteous treatment of the abutting property owners is the first step toward securing their cooperation. Under the present policy of contacting property owners by Supervisors, which is explained more fully elsewhere in this manual (see para. 130), many of the questions by property owners will have been answered prior to surveying.

Always be helpful in warning traffic of hazards. When driving a personal or Department car, conform to all the rules of the road; more than that give way to the other motorist, especially so when driving a Department car. Try to be of assistance during accidents and helpful to other motorists who may need assistance. Survey vehicles shall be parked in such a manner as not to create a hazard to the public nor an obstacle to property owners. Many property owners will provide a safe area if consulted.

130 RIGHT OF ENTRY FOR SURVEY PURPOSES

Existing laws within this State do authorize the Commissioner or his representatives to make surveys on private properties for highway purposes. The specific law is hereby quoted: "229:11 Right to Enter.

The Commissioner and his agents may enter private lands to make surveys and establish boundaries of highways."

However, it is the policy of the Department that, prior to entry on private property, permission must be requested in every case from the owner, or authorized agent, by the Survey Supervisor through personal contact or by mailing the adopted form letter containing a concise description of the proposed project enclosed with a returnable stamped postal card specifically drafted for this purpose. The postal card bearing the signature of the landowner, or other authorized party, is authorization to trespass, or he may default by failing to return card within ten days. This information will be disseminated to the Party Chief by the Survey Supervisor.

This right of entry must be respected to the fullest extent as it involves property damage. It is also the policy of the Department that only brush and small trees six (6) inches or less in diameter will be cut in wooded areas. Ornamental shrubs and trees will not be damaged in any way. Offset lines must be utilized to accomplish the above. Trees larger than six (6) inches in diameter may be cut only after special permission from landowner is received. The Party Chief shall incessantly make his party members cognizant of the fact that damage must be minimized. Care must be exercised to maintain the appearance of areas through which a survey is being made in its original or natural state. Cut brush and trees, survey stakes, risers,

flagging, and debris of any kind, must be reduced to a minimum or made as inconspicuous as humanly possible in a manner that is consistent with an expedient operation. Special care should be utilized when work is being accomplished near lawns, gardens, ornamental trees, shrubs, etc.

The assumption that "the State is going to buy it anyway" should not influence respect toward private property. Line changes are not uncommon.

The State is liable for any damages to private property by Department personnel, and the Party Chief should be able to justify the actions of his crew at all times.

When cherry, crab-apple, or locust trees of any type are cut or limbed in any area where livestock are pastured, all brush must be removed from the pastured area. This brush can cause death or serious illness to the livestock.

Filching of fruit, vegetables, or other crops will be cause for disciplinary action. There will be no scavenging on private property.

Avoid littering at all times. Refrain from careless markings with crayon, ink or paint on road surfaces, trees, walks, etc. Poor conduct of this nature reflects immediately upon the Department.

133 AUTHORITY FOR PROJECT SURVEY

The Location Engineer is directly responsible to the Highway Design Engineer for the conduct and the work of all survey parties

including Consultant Survey Parties. After approval by the Highway Design Engineer, the Location Engineer, through the Area Survey Supervisors, delegates the various projects to be surveyed to one or more survey parties selected to accomplish such work. The various types of media commonly used to guide the survey party in accomplishing the assigned work are as follows:

1. Photogrammetric plans showing proposed alignment geometrically referenced to horizontal control monuments within the project area. Generally, these monuments are a part of the State grid system.
2. Aerial photographs including cronaflex, showing approximate proposed locations with indicated limitations referenced to known physical features on the ground.
3. Original plans of certain highways on which proposed changes are indicated.
4. U. S. Coast and Geodetic Survey maps, usually enlarged, showing approximate alignment to be accomplished.
5. Traverse line plan showing proposed alignment.
6. Verbal instructions given by the Location Engineer or his representative, Division Engineer or his representative, or any other responsible person for whom the survey is to be accomplished after approval by the Highway Design Engineer.

The project number sheet, plus any of the above media which originates from the office of the Highway Design Engineer and eventually received by the Chief of Party, constitutes evidence of authority for the execution of the survey work.

135 SAFETY PROCEDURES

135.1 USE OF SURVEY RODS UNDER HIGH VOLTAGE TRANSMISSION LINES

The dangers of using survey rods under high tension lines have been heretofore inadequately publicized.

Public Service Company of New Hampshire estimates that electricity will arc from high voltage lines to a metallic conductor at the ratio of one inch to every one-thousand volts. The wooden Chicago rod that is in current use by the Department crews could conceivably prove dangerous if the rod and ground are damp.

All precautions will be taken while working directly under high voltage lines. At no time will the end of the rod be closer than ten feet to the lowest wires.

Direct measurements with rods will not be used in obtaining elevations of high voltage lines. The only acceptable methods are by triangulation or by using the range finder. (See instructions under para. 220.3.)

135.2 MINIMUM REQUIREMENTS FOR SIGN PROTECTION

The following equipment and requirements will be used by all Survey Parties when working within the limits of the traveled way upon

any highway and is intended to be considered minimum requirements by the Department.

2	-	Metal signs "Men Working In Road" (18") with stands
10	-	18" GLO CONES
6	-	Flags with staff for signs and traffic control
5	-	Vests, (flourescent orange)
5	-	Helmets (hard hats) *

*(All areas of any construction project shall be considered hard hat areas.)

135.3 LOCATION AND USE OF SIGNS

1. The signs warning the oncoming traffic shall be a minimum distance of 1500' from any man working in the highway with speed design of seventy miles an hour, and decreasing proportionately according to design speed and safety requirements, and a maximum distance of 4500' apart; and if practical, shall be placed in center of road. Under no condition shall any member of the party attempt to do any work within the traveled portion of the road until the signs are in place.
2. At least two cones will be used in combination with metal sign; additional cones placed at locations selected by the Party Chief.

3. Signs shall be moved as the work progresses so as to keep within above distances. When the work leaves the highway, such as a cut-off or lunch hour, etc., all signs shall be removed and placed so that the traveling public cannot see or read them.

135.4 GENERAL INFORMATION

If, in the opinion of the Party Chief, the signs are not adequate for the conditions, and the traveling public does not heed to caution, it may be necessary to employ flagmen or even solicit State Police or Local Police for the necessary protection.

It should be kept in mind at all times that when the motorist is blinded by direct sunlight, it is not safe to be working on the highway. Usually the progress of the work can be planned to avoid this situation.

Survey crews will not work on the highway during fog, ice and/or snow conditions, or periods of low visibility.

In order to further insure the safety of our personnel, and the traveling public, flashing dome lights on vehicles will be used as follows:

1. Whenever any of the survey party is working within the right of way limits of the highway. The vehicle shall be parked within the signed area.
2. Flashing dome lights need not be used whenever the vehicle is parked off the traveled way or shoulders

and the party is working entirely outside of the highway right of way limits.

135.5 LIFE PRESERVERS

Survey personnel, while working in an area that in any way could be considered a potential drowing hazard, must wear life preservers which are available at Headquarters' Supply Room, through requests to the Survey Supervisor in advance of needs.

135.6 CARE IN USE OF CUTTING IMPLEMENTS

Extreme care should be exercised in the use of cutting implements, such as axes, machetes, brush hooks, etc. New and inexperienced survey personnel should be given special instructions and training in the use of these implements before allowing them to operate under normal conditions with other experienced survey personnel during clearing operations. Under no condition should crew members using the above implements simultaneously be within fifteen (15) feet of each other in order to avoid accidental lacerations.

The use of powered chain saws by survey personnel is absolutely prohibited.

135.7 SAFETY HATS

Safety hats will be worn by all personnel while working on or visiting construction projects.

All hats and liners will be issued on hand receipts and these

receipts kept on file in the Highway Design Office. When an employee, having been issued a hat, terminates employment he will turn in the assigned hat and liner and reclaim his hand receipt.

It will be the responsibility of all supervisors and survey party chiefs to determine when hats will be worn, and that employees are utilizing hats at the appropriate times.

135.8 SAFETY VESTS

All Highway Design Division personnel are required to wear the blaze orange safety vest while conducting their activities on or along any traveled highway. During the deer hunting season all Highway Design Division personnel are required to wear the safety vests while conducting their field activities in any area that is or could be inhabited by hunters.

The vests can be acquired as needed through the supervisors from the Highway Supply Room.

139 CARE OF EQUIPMENT

The proper care and use of survey equipment cannot be over-emphasized. It is the responsibility of all employees using the equipment to treat it with the utmost care and to maintain it in first class condition. The efficiency, pride, and satisfaction of a job well done is generally reflected in the manner in which the equipment is maintained. Carelessness with State owned instruments and equipment will not be tolerated. The private use of State owned equipment for personal

projects, or the continual misuse of State owned equipment will be cause for disciplinary measures or termination.

In addition to observing common sense rules about the care of equipment, the following suggestions should be given particular attention:

(a) Wet tapes should be wiped dry before they are put away. Rub the dry tapes with an oily cloth to prevent rusting.

(b) If possible, level rods should be wrapped or carried in a case to preserve paint and graduation marks when transported over long distances.

(c) Never leave any equipment unattended where it might be stolen.

(d) Ice chisels must not be used as prys or to cut frozen earth. They must be used only for cutting ice.

140 USE AND CARE OF INSTRUMENTS IN THE FIELD

Careful attention to suggestions given herein will save needless wear on instruments and reduce the dangers of accidents to a minimum, besides increasing the quality and speed of the work.

(a) Equipment should be stowed in the survey vehicle in a manner that will eliminate unnecessary wear. Instruments should not be subjected to severe jolts.

The self-levelling level must be carried on a cusion of shock absorbent material, never on the floor of the vehicle. Sharp jolts can easily affect the accuracy and adjustment of this instrument by stretching the fine wires supporting the self-levelling mechanism.

(b) Tripod: Inspect the tripod legs and shoes. The leg of the wide leg tripod is of proper tightness if, when lifted to an elevated position, it sinks gradually of its own weight.

(c) Instrument case: Handle the instrument gently in removing it from and returning it to the case. It is best to place the hand beneath the levelling base in handling the detached instrument. Considerable patience is sometimes requires to close the lid after returning the instrument. If properly placed, the lid closes freely. Never force the lid, look for the obstruction and correct it.

(d) Mounting instrument: See that the instrument is securely attached to the tripod before shouldering it. Undue haste may sometimes result in costly accidents. When screwing the instrument on tripod head, it should first be turned in a counterclockwise direction until a slight jar or click, indicating that the threads are properly engaged.

(e) Sunshade: Always attach the sunshade regardless of the kind of weather. It is part of the telescope tube. In attaching or removing the sunshade or object glass cap, hold the telescope tube firmly with one hand and with the other hand twist the shade or cap to the right to avoid unscrewing the object glass cell.

(f) Carrying the instrument: Do not carry the instrument on the shoulder in passing through doorways or in climbing fences. Before shouldering the instrument, clamp the upper motion leaving the lower motion free; lightly clamp the telescope with the eyepiece down. When the level is carried, the motion should not be clamped. In passing through timber with low branches, give special sttention to the instrument; carry it under the arms with the head visible. Before climbing a fence, set the instrument on the opposite side with tripod legs well spread.

(g) Setting up in field: When setting up in the field, bring the tripod legs to a firm bearing with the plates approximately level. Give the tripod legs additional spread in windy weather or in places where the instrument may be subjected to vibration

or other disturbances. On sidehill work, place one leg uphill. With the level, place two levelling screws in the general direction of the line of levels. On pavement in sunny weather, or under most winter conditions, use "shoes" (flat wooden slats) under each leg to prevent settlement.

(h) Use instrument cover provided when conditions warrant. If the instrument should get wet, thoroughly wipe it dry before returning it to the case. Take the instrument indoors at night for further drying if necessary.

(i) Manipulation of instrument: Cultivate from the very beginning the habit of delicate manipulation of the instrument. Rough and careless treatment of field instruments is characteristic of an unskilled observer.

(j) Plate levelling screws: In levelling the instrument, the levelling screws should be brought just to a snug bearing. If screws are too loose, the instrument rocks and accurate work cannot be done. If too tight, the instrument is damaged and the delicacy and accuracy of the observations are reduced. Much needless wear of levelling screws may be avoided if the tripod head is brought about level when the instrument is set up.

(k) Eyepiece: Before beginning the observations, focus the eyepiece perfectly on the cross hairs. This is

best done by holding the notebook page, or other white object a foot or so in front of the object glass or by sighting at the sky, so as to illuminate the hairs, and then, by means of the eyepiece slide, focus the microscope on a speck of dust on the cross hairs near the middle of the field. To have the focusing true for natural vision, the eye should be momentarily closed several times between observations in order to allow the lenses of the eye to assume their normal condition. The omission of this precaution strains the eye and is quite certain to cause parallax. After the eyepiece is focused on the cross hairs, test for parallax by sighting at a well defined object and observing whether the cross hairs seem to move as the eye is shifted slightly. Hairs should remain on mark.

(l) Magnetic needle: Should always be secured except when actually in use. Always lift the needle before shouldering the instrument.

(m) Lenses: Do not remove or rub the lenses of the telescope. If necessary to clean lens, dust first with a soft, clean camels hair brush and use a very soft cloth with caution to avoid scratching or marring

the polished and coated surfaces.

(n) The apparent cause for the major proportion of survey equipment repair costs is the direct result of carelessness or the lack of adequate consideration in surmounting obstacles such as stone walls, all types of fences, rocky precipitous areas, shallow stream beds with unstable footing, snow covered icy areas as well as icy areas, etc. It is the sole responsibility of the transitman to anticipate the seriousness of these obstacles when carrying a precision instrument and to utilize assistance of other members of the party to assure absolute security of the instrument. It is also the responsibility of the Party Chief to insist constantly the above precautionary measures be fulfilled.

140.1 TESTING OF THE INSTRUMENT

Surveying instruments should be tested frequently, but adjusted only when necessary. The surveyor who is thoroughly familiar with the condition of his instrument can get excellent results even with an instrument which is not in perfect adjustment. Adjusting one part usually affects other parts. An instrument which is badly out of adjustment should be brought to the survey stock room in Concord for exchange. The following instructions are included for simple field adjustments.

In testing an instrument, these precautions should be observed.

1. Set up in the shade, but in good light.
2. Set up on firm dry ground.
3. See that the tripod legs are well spread and firmly planted and that the metal tips are secure.
4. See that tripod plate is nearly level, tripod screws well tightened, and the instrument firmly screwed on.
5. Carefully level the instrument.
6. Go through all tests in order as given in "Adjustments" in the pages following.

140.2 ADJUSTMENT OF THE TRANSIT

Order in which the various adjustments should be made:

1. Adjustment of the plate bubbles. Set up the transit and bring both bubbles to the center of their tubes by turning the levelling screws.
   (a) Rotate the instrument about its vertical axis through 180 degrees or half way around and note any movement of the bubbles away from the centers of the tubes.
   (b) Bring the bubble of each tube back one-half of the distance that it moved by turning the capstan screws at each end of the bubble tube.

(c) Relevel and rotate the instrument again and make a similar correction if the bubbles do not remain in the center of tube.

(d) Check final adjustment by noting that bubbles remain in the center of tubes during the entire revolution about the vertical axis.

2. To make the vertical wire lie in a plane perpendicular to horizontal axis, see that parallax is eliminated. Sight vertical wire on some well defined point and, with the lower motions clamped, rock the telescope slightly up and down on its horizontal axis. If the instrument is in adjustment, the vertical wire will follow the point through its entire length.

(a) If it does not, loosen the screws holding the cross wires and slightly rotate the ring by tapping lightly on one of the screws.

(b) Repeat process until the adjustment is satisfied.

3. To make the line of sight perpendicular to the horizontal axis (double centering).

(a) Sight on a point not less than 300 feet distant and clamp both plates.

(b) Plunge telescope and set another point at a distance equal to the first distance. If the instrument is in adjustment, the two points set and the point over

which the instrument is placed will lie in a straight line.

(c) Unclamp lower motion, rotate the instrument about its vertical axis, sight at the first point, and clamp.

(d) Plunge telescope and observe second point. If instrument is not in adjustment, the intersection of the cross wires will fall to one side of the second point, and one-fourth of the distance from the last point sighted towards the first point will be the correction.

(e) Move the wire reticle horizontally by loosening the screw on one side of the telescope tube and tightening the opposite screw until vertical wire appears to have moved to corrected point.

(f) Repeat the operation until no error is observed.

(g) Repeat test under (2) since the vertical wire may have rotated during above adjustment.

4. Adjustment of standards. To make the horizontal axis of the telescope perpendicular to the vertical axis of the instrument.

(a) Sight with the vertical wire on some high point (at least 25 to 30 degrees above horizontal, and clamp the plates).

(b) Depress the telescope and mark a second point at about the same level as the telescope.

(c) Plunge the telescope, unclamp the lower plate and rotate the instrument about its vertical axis.

(d) Sight on the first point. Clamp the vertical axis and depress the telescope. If the vertical wire intersects the second or low point, the horizontal axis is in adjustment.

(e) If not, mark another low point on this line and note the distance between new point and original point.

(f) Adjust by turning the small capstan screw in the adjustment-Y-bearing at one end of the horizontal axis to correct the error which is one-half this distance.

5. Adjustment of telescope bubble. The telescope bubble of the transit is adjusted by the peg method which is described in the adjustment of the Dumpy level. Set the cross wire on the true reading and move one end of the bubble tube vertically by means of the adjusting nuts until the bubble is in the center of the tube. Repeat the test until adjustment checks.

6. Adjustment of the vertical circle vernier.

(a) Bring the bubble to the center of tube. Read vertical circle vernier.

(b) If it does not read zero, loosen the small capstan screws holding the vernier, and move the vernier until it reads zero, tighten the screws and read the vernier with all bubbles in the center of their tubes to make sure the adjustment is correct.

140.3 ADJUSTMENT OF THE DUMPY LEVEL

THE DIRECT, OR "PEG," ADJUSTMENT - To make the Line of Sight Parallel to the Axis of the Bubble. Select two points A and B, say, 200 feet or more apart. Set up the level close to A so that when a rod is held upon it the eyepiece will be about a quarter of an inch from the rod. Look through the telescope wrong-end-to at the rod and find the rod reading at the cross-hair, if visible, otherwise the reading opposite the center of field. After a little experience it will be found that this can be done very accurately. Owing to the fact that only a small portion of the rod is visible it will be found convenient to set a pencil-point on the rod at the center of the small field of view. Turn the telescope toward B and take a rod-reading on it in the usual way, being certain that the bubble is in the middle of the tube. The difference between these two rod-readings is the difference of elevation of the two points plus or minus the error of adjustment. The level is next taken to B and the above operation is repeated. The result is the difference in elevation minus or plus the same error of adjustment. The mean of the two results is the

true difference in elevation of points A and B. Knowing the difference in elevation between the two points and the height of the instrument above B the rod-reading at A which will bring the target on the same level as the instrument may be computed. The bubble is brought to the center of the tube and the horizontal cross-hair raised or lowered by means of the adjusting screws on the cross-hair ring until the line of sight strikes the target. In this method the small error due to curvature of the earth (nearly 0.001 ft. for a 200 ft. sight) has been neglected.

EXAMPLE.

Instrument at A.

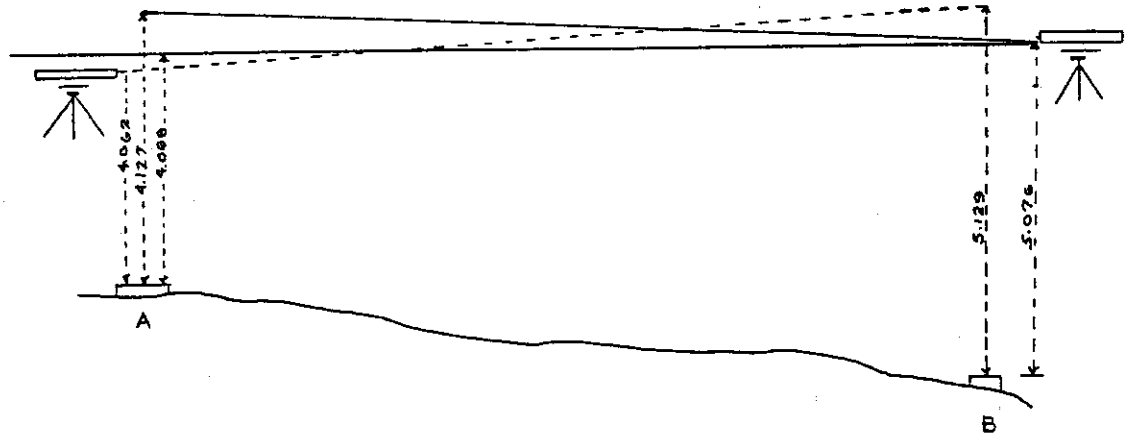
Rod-reading on	A = 4.062
Rod-reading on	B = 5.129
Diff. in elev. of A and B	= 1.067

Instrument at B.

Rod-reading on	B = 5.076
Rod-reading on	A = 4.127
Diff. in elev. of B and A	= 0.949
Mean of two diff. in elev.	$= \frac{1.067 + 0.949}{2} = 1.008$ true diff. in elev.

Instrument is now 5.076 above B.

Rod-reading at A should be 5.076 - 1.008 = 4.068 to give a level sight.



The peg method may be used for adjusting the wye level or the transit, the difference being that in the dumpy level the axis of the bubble tube is first made horizontal and then the line of sight is brought parallel to it, while in the wye level and in the transit the line of sight is first made horizontal and then the axis of the bubble tube is made parallel to it. Consequently, in adjusting the dumpy level the cross-hair ring is moved, whereas with the transit, or the wye level the adjustment is made in the bubble tube.

140.4 THE SELF-LEVELLING LEVEL

Before it is assumed that adjustments are necessary, it is essential to make sure that any apparent need for adjustment is actually due to the conditions of the instrument and is not caused by deficiencies in the test. To test an instrument properly, observe the following precautions:

1. Choose a firm support for the instrument. Usually this can be found only outdoors. The floor of a building, even when made of concrete, will deflect when the observer moves around the instrument.

2. If possible, choose a cloudy day. If the sun is shining, the work must be carried out in the shade, but in good light.
3. The instrument must have time to accommodate itself to temperature. This requires 30 minutes to an hour, depending on how great a temperature difference exists between the place of storage and the outdoor temperature. The operation of many automatic levels is very erratic during periods when the temperature ranges from near zero to sub-zero.
4. Be on the look out for creep when adjusting the circular level. Creep is caused by tripod settlement, or by the temperature of the instrument changing. This is particularly apt to happen if the instrument has just been brought out-of-doors or is exposed to body or other radiant heat. After setting a bubble or the line of sight, let it stand a few seconds to see that no movement occurs.
5. For adjustment of self-levelling level, see instructions included with each instrument.
6. It is recommended that the three blued screws that regulate the function of the levelling screws be

constantly checked for looseness. These screws, located on the lower side of the base plate, must be adjusted only with the tools furnished with instrument.

141 CARE AND USE OF STATE OWNED BOATS

The rowboats that are to be used for survey purpose are stored when not in use at the stake shed near the Highway Garage. Arrangements through the Survey Supervisor may be made to procure the boat and affiliated equipment. The boat racks, ropes, oars, and life preservers are stored when not in use at the John O. Morton Building Supply Room. The above equipment must be returned promptly to these areas when the current work has been completed.

After each day's use, the boat and affiliated equipment must remain in the protective custody of the Party Chief and not left on the site of operation overnight under any condition.

142 CARE AND USE OF STATE OWNED VEHICLES

Each party chief is assigned a State owned vehicle to transport survey personnel and equipment for the execution of the work assignment. This vehicle should always be cared for and treated in a superior manner. It should always be kept in a good state of repair and properly lubricated and maintained as prescribed within the owner's manual.

The following simple precautions and preventative maintenance measures are worthwhile:

1. Use of another member of survey party, stationed to the rear of vehicle, to guide operator of vehicle in backing into hazardous or questionnable areas.
2. Use of extreme care in driving over woods roads, and the alike, to prevent damage to underside of vehicle.
3. Maintain recommended tire pressures.
4. Applying a few drops of oil on door hinges, door locks, etc.

The Chief of Party is solely responsible for the proper care of the assigned vehicle.

No person will be issued an application for State Vehicle Operation unless he has been employed by the Highway Design Division

at least six (6) months.

All vehicles brought to the Concord Highway Garage for overnight parking must be locked if left outside in the parking lot and the key must be placed on the rack inside the garage or given to the watchman. Otherwise, the vehicle must be left inside the garage.

Use of any State vehicle to tow or push other vehicles is prohibited.

It is imperative, after taking all the necessary survey equipment from vehicle during any time of the day's work, whether working near or away from vehicle, that survey personnel habitually close all vehicle doors, windows, and tail gate. During hot summer days, the windows could be down a short distance to allow for some circulation. When the work to be performed is some distance from the parked vehicle, the vehicle should be locked to discourage pilferage.

142.1 GOVERNING POLICY

The following policy shall govern the use of State owned motor propelled vehicles:

"Any officer or employee of the State of New Hampshire who uses or authorizes the use of any State owned vehicle, or of any motorized leased vehicle, for other than official purposes -- shall be subject to penalties of applicable sections of Rule VIII

of Personnel Rules as adopted November 1951."

State owned or leased motor vehicles shall be used only for official purposes. It is State policy to interpret the term "official purposes" strictly. The use of official vehicles for such purposes as attending to personal business affairs, attendance at luncheons or other social engagements, pleasure trips and the alike, is obviously not for "official purposes" and hence illegal. Employees and officials using, or authorizing the use of, official vehicles have the primary responsibility of assuring legal use of such vehicles. Official and non-official business must not be intermingled.

Employees' families or other individuals not on official business shall not be permitted to travel in State owned vehicles except when so authorized by their respective Department Heads. Any such authorizations shall be for individual trips involving special circumstances that justify an exception to the general policy of not permitting travel in State vehicles by other than State employees on official business.

A State owned vehicle shall be operated in a manner consistent with applicable N. H. Motor Vehicle Laws and Regulations.

145 FIELD NOTEBOOKS

The field notebooks become a matter of record and therefore should receive considerable attention, forethought, and planning as to their organization and completeness.

They should be stored in a book box, along with an accurate record of all books handled by the Chief of Party, and not left on the seat of the vehicle.

The first lined page, and page numbered 1, if it is anticipated that the space will be needed, will be set up as the index page or pages. The index shall be complete and as informative as possible (see Plate No. 1).

Within any section of the notebook, when revisions or corrections are necessary, they may be made by lightly crossing out the original information and entering the new information adjacent to it. It may become necessary to cross out an entire page and relocate the information in another section of the book.

At the start of each day's work, the date, weather, and the names and duties of each member of the survey party shall be entered in all books used that day. This is a very simple procedure and yet it is vitally important that it be followed to the letter. NO OTHER METHODS OR DEVIATIONS ARE ACCEPTABLE. (See various Plates within this manual.)

Notes should never be crowded. They should be neat and legible. A soft leaded pencil, about a 3-H must be used for note keeping.

The notes for each separate operation of a survey on a given project must be identified properly by the entries at the top of the left-hand page. It should include the name and State number of the project and its character of work, such as "Alignment." The next and following pages throughout the alignment notes, or whatever the type of work may be, should be marked "Alignment Continued" or "Sections Continued," etc. If it is necessary, at some later date for various reasons, to continue the alignment in another section of the book, the above procedure would be maintained, in addition to complete cross referencing in both sections.

All superseded notes of record must be marked superseded and cross referenced fully.

Alignment and detail notes should be recorded in book(s) separate from bench lines and leveling notes.

Green pencils will be used in the field when editing notes in the notebooks. Red pencils will be used by the office forces only.

150 ADMINISTRATIVE REPORTS

The Chief of Party is responsible for many administrative reports, most of which are periodic. It is imperative that these reports be completed fully, concisely, and promptly.

150.1 DAILY REPORT OF SURVEY CHIEF (HDPC - 124 REV.)

a. Preliminary Card (yellow)

b. Construction Card (blue)

c. Finals Card (pink)

These cards must be filled out completely, correctly, legibly and in ink, mailed or sent to Highway Design Office, John O. Morton Building, Concord, New Hampshire, at the close of each day or no later than 7:30 a.m. the following day, except that the last two (2) days of the pay period will be retained by the Chief of Party, or acting Chief of Party, and submitted attached to his time sheet.

Special emphasis will be made in reporting accomplishment for each day. Quantitative remarks for any type of work, where applicable, must be included daily so that composite figures taken from the cards after the completion of the project will represent accurate values for each phase of survey work. THIS IS A MUST!

The following meal coding will be shown on cards after individuals name (see example on Page):

M-I	Meal purchased in restaurant
M-II	Lunch carried when restaurant not available
M-III	Lunch carried - no charge to State

M-IV On expenses paid by State

On designated inoperative days of a survey crew, Party Chief must fill out a preliminary card showing disposition of his assigned crew.

For military leave, sick leave or annual leave, without pay, insert "No Pay" opposite man's name in box under annual leave and sick leave. Designate under remarks the kind of leave taken if other than annual or sick.

On daily construction report card, when applicable, indicate the following:

a. Center line stage for gravel or paving: Indicate whether center line is for gravel, pavement, base course, binder course or wearing (final) course.

b. Blue-tops -- indicate number of stakes per station being set.

When two or more projects are worked on in a given survey party day, divide the day into halves and submit appropriate card for each half day. Show as follows: DAILY REPORT OF SURVEY CHIEF (1/2 DAY).

Preliminary cards will be used on code numbers not having an assigned town or project number. Opposite "Town" write in Engineering; under code use code number such as 839, and under remarks write the Town where work was performed.

DAILY REPORT CARDS

☐ HDPC-124 Rev. **DAILY REPORT OF SURVEY CHIEF** Finals ☐

Town: Bow
N.H. Proj. No. P-1111 Vehicle No. H-100
A.M. Speedometer: 20,000

Date: 5/3/72 Code: 224
Weather: Clear Time on Proj: ½+7=7½
Proj. Length Sta. 210+0 to Sta. 300+50
Roadway Sta. 210+0 to Sta. 213+0
Ledge Sta. ____ to Sta. ____
Bridge ☐ Stock Piles ☐
Supervisor Visits ☑
Field Bk. Nos. Pit-8339, Sect 9205
Borrow Pit Name & No. | Gravel Pit Name & No. Smith #4

Personnel	Last	First	AL	SL
Chief	White, J.	M-1		
Instr.	Black, R.	M-3	✓	
Rod	Green, S.	M-1		
Rod	Brown, V.	M-1		
Rod	Jones, T.	M-1		

Remarks: ☐
R'dwy. Sects. 1 % Est.
Pits 100 % Est.
Bridge ____ % Est.

Salmon

☐ HDPC-124 Rev. **DAILY REPORT OF SURVEY CHIEF** Construction ☐

Town: Goshen
N.H. Proj. No. P-5115 Vehicle No. H-200
A.M. Speedometer: 10,000

Date: 4/5/72 Code: 221
Weather: Showers Time on Proj: ¾+6¾=7½
Proj. Length Sta. 100+0 to Sta. 200+0
Stakes Sta. ____ to Sta. ____
Re-Stakes Sta. ____ to Sta. ____
Levels Sta. ____ to Sta. ____
Re-Levels Sta. ____ to Sta. ____
℄ Stage Sta. ____ to Sta. ____
Ledge Sects. Sta. 120+50 to Sta. 137+0
Blue Tops Sta. ____ to Sta. ____
Gravel Stakes Sta. ____ to Sta. ____

Personnel	Last	First	AL	SL
Chief	Davis, D.	M-1		
Instr.	Downes, J.	M-1		
Rod	Dinkel, B.	M-1		
Rod	David, W.	M-1		
Rod				

Supervisor Visits ☑ | Borrow Pit Name & No. | Gravel Pit Name & No. | Spot Paint R'dwy. ☐
Remarks: 120+50 - 127+0 - 3 per sta. | Bridge Layout ☐ | Tieing ☐ | R.O.W. ☐
☐ remainder, 4 per sta. | Field Bk. Nos. looseleaf | Curbs ☐

Blue

☐ HDPC-124 Rev. **DAILY REPORT OF SURVEY CHIEF** Preliminary ☐

Town: Alton
N.H. Proj. No. P-0011 Vehicle No. H-300
A.M. Speedometer: 30,000

Date: 2-2-72 Code: 111
Weather: Cold Time on Proj: 1+6½=7½
Proj. Length Sta. 20+0 to Sta. ?
Survey ℄ Sta. 42+50 to Sta. 57+0
Detail Sta. ____ to Sta. ____
Bench Line Sta. ____ to Sta. ____
Sections Sta. ____ to Sta. ____
Back Trav. Sta. ____ to Sta. ____
Photo Check ☐ Stock Piles ☐

Personnel	Last	First	AL	SL
Chief	Blue, V.	M-1		
Instr.	White, B.	M-1		
Rod	Black, W.	M-1		
Rod	Brown, T.	M-1		
Rod				

Field Bk. Nos. 9199 R.O.W. ☐
Remarks: Completed curve #1 Supvr. Visits ☑
☐
Survey ℄ 41 % Est.
Detail ____ % Est.
Section ____ % Est.

Yellow

Daily report cards without stamps will be used in the Concord area and in areas designated by the Survey Supervisors.

All Party Chiefs will be held directly responsible for the processing of all daily report cards in accordance with these instructions.

150.2 VEHICLE MILEAGE REPORT (HMD 172-REV. 66)

This report will be completed and forwarded, by mail or other available means so as to reach the Highway Design Office no later than Monday morning of each week. Be certain that the daily "out mileage" reading shown on daily report card agrees with resultant mileage figures shown on mileage report. An adequate description of travel must be shown by day on the reverse side to document the miles reported. The columns on front of the form, for gas and oil, are to be filled out only for gas and oil purchased in public stations. The back of the form must be filled out for "point to point" net mileage listed separately from "on the job mileage."

150.3 STATE MOTOR VEHICLE ACCIDENT REPORTS

1. All accidents will be reported on Report of Motor Vehicle Accident forms. These forms will be filled out completely or as much as possible.

2. Witness statements will be obtained, if possible, and forwarded with the accident report.

3. Four copies of every accident report are required by this office.

4. All accident reports will be forwarded within 48 hours, to State of New Hampshire, Department of Public Works and Highways, John O. Morton Building, Highway Design Division, Survey Section, Attention: Assistant Location Engineer.

5. Blank forms of Motor Vehicle Accident forms will be carried in all survey vehicles. Extra forms can be procured from the Survey Supervisors.

150.4 MOTORIST ASSISTANCE REPORT

This form must be filled out completely upon completion of each assist and forwarded through your Survey Supervisor to the Location Engineer at Highway Design headquarters.

150.5 PERSONNEL ACCIDENTAL INJURY OR OCCUPATIONAL DISEASE

A. FORMS

1. 8a WCA - To be made out by injured employee and signed by him. If he is unable to do so, the Chief of Party or Supervisor can make it out, with a note of explanation attached. Supervisor or Chief of Party will sign on employer's line.

The Employer's copy (white) is to be forwarded to Highway Design Division, Survey Section, Workmen's Compensation Agent. The Employee's copy (yellow) to be given to the employee for his record. This form

will be used alone only where no treatment is required beyond first aid in the field, and where no doctor is involved.

2. 8-WC - The Survey Supervisor or Chief of Party will fill out this form with all the necessary information to substantiate the claim for Workmen's Compensation. The physician and hospital name and address is essential. The Labor Department copy (white), Insurance Claims copy (yellow), and Employer's Copy (pink) are to be forwarded to Highway Design Division, Survey Section, Workmen's Compensation Agent. All witnesses to the accident must make out a statement in their own handwriting and forward with this form.

B. INSTRUCTIONS

1. Chief of Party will forward all accident forms and statements through his Supervisor or U. S. Mail Service to reach the Highway Design Division, Survey Section, Workmen's Compensation Agent, Concord, N. H. 03301, within 36 hours or less, after an accident. Blank accident forms will be issued, as needed, to Chiefs of Party by their Supervisors.

2. Survey Supervisors will personally investigate and submit a full written report to his Workmen's Compensation Agent, concerning all accidents to employees under his jurisdiction.

3. Survey Supervisor will notify his Workmen's Compensation Agent when an injured employee under his jurisdiction will be absent from work seven (7) consecutive days or more, and notify the date and time when he returns to work. THIS IS A MUST.

C. GENERAL INFORMATION

1. Injured employees disabled over seven (7) consecutive days will be placed on Workmen's Compensation and paid in accordance with Workmen's Compensation Law. For disability of less than seven (7) days, sick or annual leave will be utilized.

2. All reporting forms are available from your Survey Supervisor, or from your temporary assigned headquarters.

3. All bills related to injured employee will be made out in his name and forwarded to your Workmen's Compensation Agent.

4. To determine the date of injury of an occupational disease, such as poison ivy, etc., the first date of

treatment by a licensed physician shall be taken as the date of injury.

5. If additional information is desired, contact the Highway Design Division, Survey Section, Workmen's Compensation Agent, Concord, N. H., through your Supervisor.

150.6 BI-WEEKLY TIME AND EXPENSE REPORTS

Time Reports on Form No. BWTR 7

Expense Reports on Form No. BWES-7A - Rev. 6/7/65

These forms must be in the Highway Design Division Office by Friday and no later than Monday, following the closing of the pay period. They must be signed by the individual and initialed by the Party Chief. All Daily Report of Survey Chief Cards, Annual Leave and Sick Leave Slips must be in the Highway Design Division Office in order to substantiate the Time and Expense Reports. If a holiday comes at the end or beginning of the pay period, all of these reports must be in by Friday morning.

The following Survey Work Class Codes will be used on Time and Expense Reports:

111 PRELIMINARY SURVEY

Preliminary Engineering Survey and Property Survey in support of any proposed Department Construction, Maintenance or Public Service Activity. This code will not be used for survey on any project that has been

advertised for bids. This charge cannot be used on or after date of advertising.

112 COMPUTING AND ESTIMATING

Plotting of survey data, etc., in the Division Offices on projects that have not been advertised for bids.

221 CONSTRUCTION SURVEY

All Engineering Survey and Property Survey in support of a Construction Project that occurs on or after the date that the project is advertised for bids. This work includes original survey of proposed borrow and gravel areas, crushed gravel stock piles, classified and unclassified uncovered ledge.

224 FINAL SURVEY

All survey work incurred in connection with the Final Audit process. This work normally consists of taking final cross sections of completed roadway, pits, and any other survey that, for reasons of payment, requires measurement before and after stages of construction. Included in this classification of work is all survey necessary to establish Reference Bounds for the completed project.

883 ENGINEERING - Annual Leave

884 ENGINEERING - Sick Leave

State of N.H. Department of Public Works & Highways

BI-WEEKLY TIME REPORT

SAMPLE

BWTR-7

Name JOHN E. JONES (SIGNATURE)

Class of Labor Code: _____

Position Number _____

Day Rate _____

PERIOD ENDING Dec. 23, 1971

Employee Number _____

P.(0): ___ T.(3): ___

PROJECT NAME	PROJECT OR SECTION NO.	SYSTEM	SURFACE	WORK CLASS CODE	DAY OF PAY PERIOD — EXPENSE DISTRIBUTION COLUMN														DAY NO. OF PERIOD TOTAL	AMOUNT EARNED
					1 FRI.	2 SAT.	3 SUN.	4 MON.	5 TUE.	6 WED.	7 THU.	8 FRI.	9 SAT.	10 SUN.	11 MON.	12 TUE.	13 WED	14 THU.		
Gilsum	P-1824			111	1														1	
Woodstock	P-7889-G			221				1											1	
Stewartstown	P-7994			224					1										1	
Engineering				839						1									1	
Misc. Engineering-Div. 3	1832-H			///							1								1	
Engineering				884								1 S							1	
Engineering				886											1 ML				1	
TOTAL ACCOUNT CODE →	3002																			
Engineering (Jury Duty)				887												1			1	
Engineering				888													1 C		1	
Engineering				883														1 A	1	
TOTAL ACCOUNT CODE →					1			1	1	1	1	1			1	1	1	1	10	

34 DIV. NO.

11 FOREMAN OR GROUP NO.

AUDITED FOR COMPTROLLER BY _____

APPROVED BY _____

State of N.H. Department of Public Works & Highways

BI-WEEKLY TIME REPORT

SAMPLE

BWTR-7

Name JOHN E. JONES (SIGNATURE)

Class of Labor Code: _____

Position Number _____

Day Rate _____

PERIOD ENDING Jan. 6. 1972

Employee Number _____

P.(0): ___ T.(3): ___

PROJECT NAME	PROJECT OR SECTION NO.	SYSTEM	SURFACE	WORK CLASS CODE	DAY OF PAY PERIOD — EXPENSE DISTRIBUTION COLUMN 1 FRI.	2 SAT.	3 SUN.	4 MON.	5 TUE.	6 WED.	7 THU.	8 FRI.	9 SAT.	10 SUN.	11 MON.	12 TUE.	13 WED	14 THU.	DAY NO. OF PERIOD TOTAL	AMOUNT EARNED
Engineering				885	1 H														1	
Carroll	P-7438			112				1											1	
Gilsum	P-1824			111					1	1	1				1	1	1	1	7	
Gilsum	P-1824			885								1 H							1	
TOTAL ACCOUNT CODE →	3002				1			1	1	1	1	1			1	1	1	1	10	
TOTAL ACCOUNT CODE →																				

34 DIV. NO.

11 FOREMAN OR GROUP NO.

AUDITED FOR COMPTROLLER BY _____

APPROVED BY _____

State of N.H. Department of Public Works & Highways

BI-WEEKLY EXPENSE SHEET

SAMPLE

BWES-7A
Rev. 8-1-69

Name JOHN E. JONES

Position Number _____

PERIOD ENDING December 23, 1971

Employee Number _____

DATE	DAY OF PAY PERIOD	MILEAGE		MEALS - AMT'S			HOTEL	DAILY SUB-SISTENCE	COMMON CARRIER	MISCELLANEOUS						TOTAL EXPENSE
		NO.	AMOUNT	MORN.	NOON	EVE.				DESCRIPTION	OBJECT	AMOUNT	DESCRIPTION	OBJECT	AMOUNT	
	1				1.75											
	2															
	3															
	4				1.80											
	5				1.65											
	6				1.85											
	7				1.90											
	8				-0-											
	9															
	10															
	11				-0-											
	12				-0-											
	13				-0-											
	14				-0-											
TOTALS				*	8.95 *	*		*								8.95

May have Daily Subsistance of $1.50

Official Hdqtrs. _____

Checked By _____

Approved By _____

			MEALS *	SUBSISTENCE *
34	11	TOTAL $ OF ABOVE WHEN: ON OVERNITE TRAVEL STATUS →		
DIV. NO.	FOREMAN OR GROUP NO.	NOT ON OVERNITE TRAVEL STATUS →	8.95	

I certify that the account and schedule annexed are just and true in all respects; that the distances for which charge is made have been actually and necessarily traveled on the dates specified; that except as shown no lodgings were shared jointly with others nor were meals or lodgings furnished without charge by a state agency or with or without charge by a member of my family, by another state employee or a member of his family; that the amounts as charged have been actually paid by me for travel and expenses incurred on official business only; that no part of the account has been paid by the state, but the full amount is justly due; that all expenditures included in said account were made under prior authority therefor or under such circumstances as to render the securing of prior authority impracticable; that the expenses for which no vouchers were obtained were incurred under such circumstances as to render the taking of vouchers impracticable, as fully explained herein.

John E. Jones

Employee Signature

AUDITED FOR COMPTROLLER BY } _____

State of N. H. Department of Public Works & Highways

BI-WEEKLY EXPENSE SHEET

SAMPLE

BWES-7A
Rev. 6-7-65

Name JOHN E. JONES

Position Number

PERIOD ENDING Jan. 6, 1972

Employee Number

DATE	DAY OF PAY PERIOD	MILEAGE NO.	MILEAGE AMOUNT	MEALS NO. TYPE	MEALS AMOUNT	HOTEL	DAILY SUB-SISTENCE	COMMON CARRIER	MISCELLANEOUS DESCRIPTION	OBJECT	AMOUNT	DESCRIPTION	OBJECT	AMOUNT	TOTAL EXPENSE
	1				-0-										
	2														
	3														
	4				1.55										
	5				1.60										
	6				1.75										
	7				1.80										
	8				-0-										
	9														
	10														
	11				1.65										
	12				2.00										
	13				1.90										
	14				1.85										
TOTALS					14.10 *		*								14.10

May have Daily Subsistance of $1.50

Official Hdqtrs.

Checked By

Approved By

34
DIV. NO.

11
FOREMAN OR GROUP NO.

TOTAL $ OF ABOVE WHEN:

	MEALS *	SUBSISTENCE *
ON OVERNITE TRAVEL STATUS →		
NOT ON OVERNITE TRAVEL STATUS →	14.10	

I certify that the account and schedule annexed are just and true in all respects; that the distances for which charge is made have been actually and necessarily traveled on the dates specified; that except as shown no lodgings were shared jointly with others nor were meals or lodgings furnished without charge by a state agency or with or without charge by a member of my family, by another state employee or a member of his family; that the amounts as charged have been actually paid by me for travel and expenses incurred on official business only; that no part of the account has been paid by the state, but the full amount is justly due; that all expenditures included in said account were made under prior authority therefor or under such circumstances as to render the securing of prior authority impracticable; that the expenses for which no vouchers were obtained were incurred under such circumstances as to render the taking of vouchers impracticable, as fully explained herein.

JOHN E . JONES

Employee Signature

AUDITED FOR COMPTROLLER BY

885 ENGINEERING - Holiday

886 ENGINEERING - Military Leave

887 ENGINEERING - Jury Duty

888 ENGINEERING - Compensatory Leave

839 ENGINEERING

(Housekeeping) Due to inclement weather, unable to perform survey work on project, sharpening tools, cleaning transits, etc. (Book work - computations - cross referencing, etc., that is pertinent to the project survey should be charged to the project under a Work Class Code, such as 111, 221, 224.)

Note: See Sample Time and Expense Reports

150.7 GRADE STAKES REPORT

Grade stakes, by number of bundles, on hand at all Division Headquarters, will be reported to Survey Headquarters, Concord, N. H., the first of each month. This report will be sent to Survey Headquarters via teletype by the senior Chief of Party assigned to the Division.

150.8 INVENTORY OF SURVEY EQUIPMENT

All Survey Equipment consisting of nonexpendables and special equipment in possession of each State Survey Crew must be inventoried the first week in January of each year. Inventory forms will be issued, and the completed forms collected by the Area Survey Supervisors.

150.9 EMPLOYEES' RECORD FORM

This form will be submitted to the Survey Office, Concord, by the Chief of Party for all personnel in his party who are either reporting for work, terminating or transferring to another Division.

150.10 LETTER OF TERMINATION

An employee who is terminating his services is expected to submit a letter to the Location Engineer on standard size paper ($8\frac{1}{2}$" x 11") at least two weeks prior to his termination. The letter will state the date and hour of his termination.

155 REPORT OF STOLEN EQUIPMENT

The following procedure will govern the action of survey parties, including those private parties contracted to do work for the State of New Hampshire, in reporting violations such as stealing, willful destruction, etc., of State owned property, especially the survey roadway safety signs and accessories.

1. Immediately record all pertinent information that will expedite the apprehension and arrest of such violators. Be specific as possible as to the number and type by description of the items involved, and every detail concerning the violator, or violators, including name if available. Include the full names of all witnesses and the name of the Area Survey Supervisor who has jurisdiction over the work being performed. In most cases concerning safety signs and accessories, individuals commit these violations with or from a vehicle, thus time is of utmost importance. Ascertain the data on the registration plates, plus any other features of the vehicle itself.
2. Immediately relay this information by telephone to the Location Engineer's Office. The recipient there, in turn, will relay it to the State Police.

160 NEW HAMPSHIRE PLANE COORDINATE SYSTEM

With the ever increasing land values and the more complex and critical construction design standards, it is no longer permissive to execute highway surveys with the short-range objective of serving only the immediate needs of construction or to base them on assumed horizontal and vertical data. Whenever it is possible, utilize datum which is part of the State Grid System. With this in mind, the Department, through the utilization of the geodimeter crew, and the contracting of consultant firms to furnish aerial photogrammetric plans to the Department, has expanded the New Hampshire Grid System in various locations throughout the State.

The above indicated trend has underlined the need of converting existing geodetic positions to plane rectangular coordinates and of computing and expressing the results of precise control surveys in terms of some standard plane coordinate system.

In the early 1930's the U. S. Coast and Geodetic Survey established a coordinate system for each State in the United States. In designing the plane coordinate systems, they decided to hold the distortion between the sea level curved surface of the earth and the projection plane to less than 1 part in 10,000. Due to the curvature of the earth, this meant that the maximum width of area which could be projected on a single plane surface would be about 158 miles. Thus, in the case of a State the size of New Hampshire, this results in a plane coordinate system, Transverse Mercator, consisting of one zone. The

central meridian is geodetic longitude of 71°-40'-00.000".

Use of the New Hampshire Coordinate System provides the following benefits:

(a) All control surveys are on a single datum, and thus the relationship of one survey to others is established.

(b) All subsequent surveys can originate and close at stations of known position and reliability. Hence the reliability of the new survey can be easily determined and appropriate adjustment applied.

(c) Points are permanently located, and can be readily reestablished if monuments are destroyed.

(d) Route surveys for highways, or other projects, can be started at various points along the route with assurance that the survey sections will "fit," when tied together.

(e) A convenient method for indexing property descriptions, route surveys, etc., is automatically provided.

For a more detailed description of the State Plane Coordinate System and further computations see the "Manual of Plane-Coordinate Computation," U.S.C.G.S., Spec. Pub. No. 193.

160.1 SPECIFICATIONS, HORIZONTAL

Methods, procedures and equipment used for primary horizontal control surveys shall be sufficiently precise to insure second order accuracy.

If a survey fails to conform to second order standards prior to adjustment, a resurvey shall be made.

Bearings, or azimuths, of all lines and coordinates of all points shall be based on the State Plane Coordinate System without exception.

Horizontal distances shall be reduced to the State Plane Coordinate System datum prior to adjusting the survey by applying:

a) The appropriate elevation factor.

b) The appropriate scale factor.

The survey shall be adjusted by an approved method prior to computing coordinates, bearings, or distances.

Only coordinates, bearings and distances computed from and consistent with the adjusted survey shall be used for design or other purposes.

All subsequent preliminary surveys shall be adjusted to the primary horizontal control survey.

160.2 SPECIFICATIONS, VERTICAL

Methods, procedures and equipment used for primary vertical control surveys shall be sufficiently precise to insure third order accuracy.

If a survey, or any part thereof, fails to conform to third order standards prior to adjustment, a resurvey shall be made.

All level lines, loops, or nets shall be adjusted prior to computing elevations of points on the survey.

Elevations of all points shall be based on the 1929 Mean Sea Level Datum.

All subsequent level surveys shall be adjusted to the primary vertical control survey.

Locate points where convenient for subsequent surveys where least likely to be disturbed.

160.3 MONUMENTATION

References for all monuments established as part of the New Hampshire Grid System shall be made in the field either to permanent natural objects or to additional points set nearby. In addition, a witness post adjacent to each monument at a conspicuous height above the ground will be set.

160.4 CONTROL MONUMENTS FOR INTERSTATE HIGHWAYS

The fact that modern design criteria, especially on Interstate Highways, establish the necessity of extensive right of way taking of an irregular pattern, places the ordinary right of way bound in locations that make them impractical for the purpose of reestablishing the center line of the barrels. It has therefore become necessary to devise another method of controls, in addition to the right of way bounds. This is being done by placing monuments (bronze tablets) at or near the beginning and at the end of tangents, and at intermediate points necessary because of grade crests, in a manner by which it will be possible to sight without obstruction from one tablet to another within the tangent area. In areas where two barrels of the Interstate Highway are close

together, both barrels may be geometrically related by angle and distance to one set of control monuments, otherwise, each barrel will be monumented separately.

The monuments must be set in earth which is stable and not subject to movements due to the elements. Every opportunity to set the bronze tablets in acceptable ledge outcroppings or permanent structures that can be occupied with an instrument, will be utilized. The Highway Design Engineer has delegated the responsibility of selecting monument locations to the office of the Location Engineer.

For standard specifications of monuments and bronze tablets, see Plates 65 and 66.

The monumentation and the second order traverse type control work accomplished with an electronic measuring instrument and compatible theodolite will be started near the completion of the construction of Interstate projects. The traverse will start and end, properly adjusted, to existing U.S.C. & G.S., or previously established monumentation, that is part of the existing New Hampshire Plane Coordinate System.

The above conforms with the memorandum of recommendation dated July 20, 1966, from H. G. Hersey, Location Engineer, to R. A. Brunel, Highway Design Engineer, and memorandum dated May 23, 1967, subject: Right of Way Lines on Plans, from R. A. Brunel, Highway Design Engineer.

PRELIMINARY SURVEYS

SECTION II

INDEX

236.3 FIELD NOTES

236.4 INPUT DATA

236.5 OUTPUT DATA

210 DEFINITION - PRELIMINARY SURVEY

The definition of a preliminary survey insofar as this Department is concerned is any survey that is made at any time prior to the advertising date of any project to be constructed under contract, or the first day of construction on projects other than contract.

214 GENERAL PROCEDURE

The notes of the preliminary survey must show the actual physical conditions as they are at the time the survey is made. Particular attention must be given to all details underground, on the surface, or overhead, which may in anyway affect the location of the proposed highway. The notes must be complete and neatly entered in the notebooks.

Before starting the survey the Chief of Party should have obtained from his superiors, as previously discussed, (see Section I, Para. 133) all the necessary information, such as the location of convenient U.S.C. & G.S., U.S.G.S. or Department bench marks, project number and charge code, and other necessary data.

After permission from all known property owners to survey has been received, the preliminary survey generally proceeds in the following manner:

1. From information mentioned above, establish the center line throughout the project; first run in tangent lines then station according to prescribed methods outlined in this manual, followed by traverse line for closure.

2. Should any unforeseen conditions, prohibitive in nature, such as excessive muck, old cemeteries, municipal water facilities (wells, etc.) be discovered during any part of the initial phase of the survey, they should be immediately brought to the attention of the Area Survey Supervisor who in turn will procure further instructions from appropriate authorities, thru channels, relative to the above mentioned conditions.
3. Establish bench marks and levels throughout project.
4. Take detail along main line.
5. Take cross sections along main line. During this phase of the survey it is usually advantageous for the Chief of Party to have his transitman continue with cross sections while he contacts property owners for property line information, cesspools, sewer, leaching bed locations, etc., PROVIDED, he has not had the opportunity to procure this information on days of inclement weather.
6. Traverse line surveys on side streets, railroad crossings, etc.
7. Make grid surveys where required.
8. Make reconnaissance with Survey Supervisor over entire project as a check on the completeness of the survey.

9. Complete check on books for indexing, cross-referencing, proper page headings, dates, lined-out superseded information, recording book numbers and nature of work in Party Chief's record book, etc.

10. All survey procedures will include adequate checks to a degree commensurate with the character of the work to insure the required accuracy.

215 ALIGNMENT

The alignment on all surveys should be carefully run as it is the basic control for all phases of the survey.

There are certain procedures which, if carefully followed, will materially increase the accuracy of line work done with the transit. With the use of controls set by geodimeter and theodolite, errors which previously went unnoticed or were ignored became apparent, especially when the survey crew is running a line which will close on control points set by the geodimeter crew or by consultant photogrammetric surveys. The procedures mentioned hereafter should be followed in all alignment work.

Ties to horizontal controls, to set the location of the center line, will be provided where available. When photogrammetry is not available the line will be shown on other available media mentioned heretofore.

When extending a tangent, the line should be prolonged by "double centering" as follows:

The instrument man sights on his backsight, telescope erect, plunges the telescope, and sets a point ahead on line. He then turns the telescope by loosening the lower motion, sights on his backsight, telescope inverted, plunges the telescope and sets a second point ahead. The first and second points will rarely coincide. The difference between the first and second points cannot be greater than 0.01 feet per 100 feet of foresight. If this accuracy is not attained the transit should be releveled and the complete procedure repeated. The midpoints obtained must agree or the procedure repeated again. When this midpoint is finally located it will be a nail in a flushed stake and labeled P.O.T. on the reference stake.

When setting a P.O.C. (point on curve), the same procedure will be followed, with the modification of turning the appropriate deflection angles.

All angles will be turned in a clockwise direction starting with the backsight on the back tangent and proceeding as follows:

With the telescope erect, sight zero on the back tangent, turn the angle to the forward tangent, record the clockwise angle. Loosen the lower motion, sight the first point with the telescope plunged, and turn the angle to the second point. When reading the second angle, care should be taken to read the same vernier as on the first angle. Repeat this procedure, once direct, once inverted. Divide the accumulated angle by four. The resulting angle must agree with the first angle recorded withon 0°0'30" or the procedure repeated.

The point occupied and both points sighted, the observed angles and computations should be clearly recorded in the fieldbook as shown on Plate Nos. 2 - 10, incl.

To lay out a given angle, as in setting the head tangent on a calculated center line:

Sight zero degrees on the given tangent; turn the desired angle from left to right, so that you always read the left vernier, with the greatest accuracy possible with the instrument; set a point the greatest distance possible from the transit on the desired forward tangent. Determine the actual angle established by the method described above. Calculate the difference in the actual and desired angles, if any. Adjust the point set as required and repeat the procedure again until there is no adjustment required.

Horizontal control monuments are placed at intervals of approximately two miles along the existing roadway where photogrammetry has been obtained. When center line is in the proximity of these monuments, ties to center line will be provided and used to correct any errors which exist in the field. The tangents will be run in each direction from the monuments and intersected at the nearest P.I. to the midpoint between two sets of monuments.

Upon completion of the P.O.T. line, stationing at fifty-foot intervals will proceed. All points will be on flushed stakes with a reference stake noting the station. The stationing will run in a south to north, or west to east direction.

In order to find the flushed center line stake under adverse conditions, such as deep snow, the following procedure in respect to reference stakes, (sometimes called witness stakes) and risers will be utilized on every project: risers will be placed one (1) foot to the right of the center line stake on tangents and one (1) foot from center line stakes to the outside of the curves. The reference stakes will be placed on the opposite side of the center line stake from the riser and six (6) inches from the center line stake.

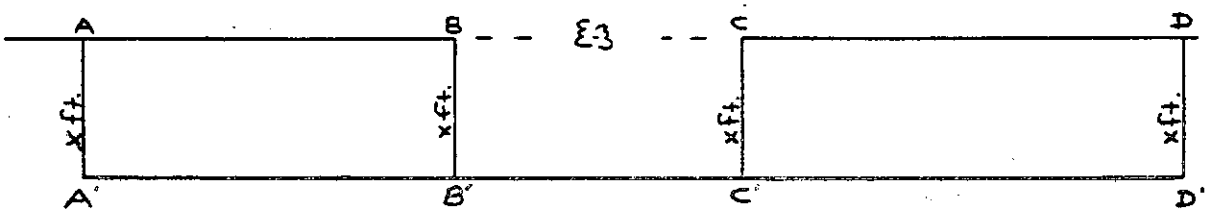
For alignment, see Plates 2 - 10, incl.

215.1 SURVEY LINE OFFSETS

The center line offset method most acceptable by this Department is the right angle offset and will be performed in the following manner:

Set a P.O.T. at "A" and "B," at least 200 feet apart, if possible. Set offset points A' and B' at 90° to the P.O.T's. A and B at identical distances from the center line. Using points A' and B' as control, double center the line beyond the obstacle and set points C' and D' a minimum of 200' apart, if possible. Points C and D are set back on center line by reversing the procedure used to set points A' and B'. The offset distance will have the greatest effect on this method so the utmost accuracy in measuring must be attained.

Other methods of offsetting may be used in isolated cases, but must first be cleared through the Survey Supervisor.



215.2 BOOKS OF TABLES

Survey personnel, as well as office personnel, will use data from HIGHWAY CURVES by IVES and KISSAM and TRANSITION CURVES FOR HIGHWAYS by JOSEPH BARNETT.

IVES and KISSAM tables are based on the arc definition. The principal change in procedure lies in the fact that these tables establish the length of radius for a one (1) degree curve at 5729.578 feet (use 5729.58).

Survey, as well as design, will use the tabular values as shown in Table 10 plus the appropriate T and E corrections as shown on Page 368 of IVES and KISSAM. For chord corrections, Table II, Page 90, will be used as shown; however, the policy for work in the field to establish 25-foot stations within curvatures 10° or greater will be followed.

215.3 SPIRAL CURVES

Spiral curves will be utilized on all Primary and Interstate alignment within curves of one (1) degree or more, (see Plates 11 - 21, incl.) unless otherwise specified. Simple and compound curves will be used in all other cases.

216 CHAINING

Chaining must be carefully done, as errors will cause difficulties through the course of the design, layout, and construction of the project.

The standard drag chain gives an accurate measurement of 100.00 feet at 68° F. The chain expands at warmer temperatures, and contracts

at temperatures below 68° F. Measurements must be adjusted to standard temperature (68° F.) to be correct. This is most easily done by adjusting the point on the chain held by the head chainman to compensate for temperature. The rate of expansion for most steel chains in use is 0.000 645' per degree per 100' or 0.01' per 16 degrees change in temperature, (see Plate No. 63). Thus, at 52° the chain should indicate that 100.01' is being measured per station. At 04° above zero, this distance would be chained 100.04', still a true distance of 100.00'. As the chain measures too short at high temperatures, and too long at low temperatures (a long chain measures short, and a short chain measures long); confusion on when to add and when to subtract the correction often arises if the temperature correction is not applied directly to each measurement. The observed temperature, and the correction per 100' that was applied to the chain should always be recorded in the traverse notes. If not applied directly to each increment measures, the correction must be subtracted when "measuring" and added when "laying out" in cold weather.

As an example: A crew measures 473.75' between two monuments at a temperature of 34° F., applying no correction. As the chain is contracted, the temperature correction must be subtracted. Computing the correction: 473.75 (68-34) 0.000645 = 0.1039 we find 473.75 - 0.10 = 473.65' the true distance between the monuments. To lay out a distance of 473.75', the crew would have to measure a distance of 473.75' plus the correction, or 473.85' indicated by the chain.

All chained measurements should be horizontal, with the chain at its correct tension. The tension required for a 100' steel chain

supported at the ends varies from 10 to 23 pounds approximately and can only be determined by comparisons against other calibrated chains.

The head chainman and rear chainman should use a hand level to insure that the tape is level. Sixteen ounce plumb bobs should insure a minimum of wind deflection under most conditions.

In uneven terrain, it is preferable to break chain, always in 50' increments or less, or to slope chain, provided the vertical angle can be accurately determined, (see Plate No. 62). Slope chaining, properly done, leaves less chance for error than breaking chain, and is preferable for slopes where frequent breaking chain would be required. The preferred method of slope chaining is with the transit set up over the rear point, the rear chainman measuring directly to the horizontal axis of the transit, and the head chainman holding the foot mark, taped reversed, on a hub and tack.

When chaining in the vicinity of railroad tracks, UNDER NO CONDITION will the steel chain be allowed to touch any rail. The Chief of Party will personally direct operations involving this work. Crossing the two rails simultaneously with a metallic object activates safety mechanisms at distant dispatching centers. These alarms must be immediately cancelled out by the railroad authorities causing them unnecessary expense and lost time.

The geodimeter may be utilized to measure across railroad tracks when adverse conditions are encountered.

217 ERRORS

In the measurements of surveying, instrumental errors arise from imperfections or faulty adjustment of the devices with which measurements are taken; personal errors occur through the observer's inability to read the instruments exactly; and natural errors occur from variations in the phenomena of nature such as temperature, humidity, wind, gravity, refraction, and magnetic declination.

MISTAKES are unintentional faults of conduct arising from poor judgment, or from confusion in the mind of the observer. Mistakes have no place in a discussion of errors. They are detected and eliminated by checking all work.

217.1 ERRORS IN TRANSIT WORK

1. Instrumental Errors. The adjustments, even though carefully made, are never exact. Likewise, the graduations are not perfect, and the centers are not absolutely true.

   Errors in horizontal angles due to non-adjustment of plate levels or of horizontal axis become large as the angle of inclination of sight increases.

   Non-adjustment of the line of sight becomes of consequence only when the telescope is not plunged.

   Errors due to instrumental imperfections or non-adjustments are all systematic. By proper methods of procedure, usually by double-sighting, they may be eliminated or reduced to a negligible quantity. The

systematic part of the error due to inclination of the vertical axis is eliminated by double centering.

In order to minimize instrument error, the transit or level should be checked for adjustment prior to the start of each new job or immediately after the instrument has been subjected to abnormally hard usage.

A few minutes spent with the "peg" test or the collimation test will tell whether or not the instrument is badly out of adjustment.

If the transit or level is found to be grossly out of adjustment, the instrument should be sent to Concord for repair, through the Survey Supervisor, accompanied by documentation stating the user's version of the instruments faulty conditions.

2. Personal Errors. Personal errors arise from the limitations of the human eye in setting up and levelling the transit and in making observations. The transit may not be set up exactly over the point; the plate bubbles may not be centered exactly; the verniers may not be set or read accurately; parallax may exist in focusing; and the line of sight may not be directed exactly at the point.

3. Natural Errors. Sources of natural errors are (a) settlement of the tripod; (b) unequal atmospheric refraction; (c) unequal expansion of parts of the

telescope due to temperature changes; and (d) wind, producing vibration of the transit or making it difficult to plumb accurately; (e) failing to observe long backsights or foresights.

217.2 ERRORS IN CHAINING

Errors in chaining are due to:

1. Chain not level - use of the hand level, which should be frequently checked for adjustment, will eliminate this source of error.
2. Improper tension on chain - use of spring balances, when the degree of accuracy requires, and practice chaining over a known distance by the chainmen will eliminate the greatest part of this error.
3. Chain not exactly of true length - usually is caused by kinks, but variations are also found in new tapes.
4. Improper temperature corrections - the chain temperature may not be exactly the same as the observed air temperature, as when chaining on a 50 degree day over snow covered terrain. For this reason the temperature, the correction used, and the conditions should always be recorded in the fieldbook along with the measurements.
5. Wind - work can usually be scheduled to avoid chaining in open terrain on windy days.
6. Estimation of hundredths on the chain.

The MISTAKE of the wrong "go-ahead" from a P.C., P.T., or P.O.T. can be quickly discovered by check chaining the full distance from the station preceding the odd stationed point to the next even station.

Mistakes made in reading the chain can be discovered by checking the foot either side of the one read. Care should be taken to hold "0," not the end of the graduated extra foot, and to avoid holding "49" for "50" or "99" for "100" due to the graduated last foot on the chain.

218 TRIANGULATION

When the center line of a proposed highway crosses a wide channel where a bridge will be built, the distance across the channel must be measured with the greatest possible accuracy. In such cases the Location Engineer should be informed and he will send the geodimeter crew to make the measurement.

In the event that the geodimeter crew is not available, the distance can be measured by triangulation. This work should be done with a high degree of accuracy using proper tension, temperature corrections and a level calibrated tape. The points should be of reasonable permanence so as to be of use when the construction survey or structure layout is made.

It is desirable to have two base lines, one on each side of the stream, and each of a length about equal to or greater than the length of the proposed structure. This is not always possible because

of terrain or topography.

Both base lines should be measured several times or until the Party Chief feels he has the best average distance. Failure to attain the proper distance on the base lines could result in an error of several inches on a long span.

The angles should be turned and read to thirty seconds or less. The angles should be turned at least six times using the plunging method with the first and sixth angles read and the sixth angle varying not more than fifteen seconds from the first.

When the Party Chief feels the highest degree of accuracy possible has been attained the computations can be performed in the field, but the final computations will be done by C.O.G.O.

219 BENCH MARK LEVELS

Level work is of the utmost importance, since the grade line, all earth work and drainage are designed from the level notes. The Party Chief shall thoroughly train the members of his party in the proper methods and accuracy required for this work.

It is the policy of the Highway Department to use United States Geological Survey Datum, ordinarily mean sea level, and mean low water along coast where tidewater is involved, to correspond with Government charts and maps. A near complete record of all known bench marks is maintained at the Concord office. A tie-in shall be made to the datum of any previous survey at either end, or crossing, of your survey.

Bench marks provide a series of semi-permanent marks of reference of known accurate elevation at frequent points along the survey line.

Bench marks shall be established at:

(a) Approximately 500 feet intervals in level country.

(b) At 50-foot difference in elevation in hilly country.

(c) On urban surveys one per city block.

(d) Any others that may be considered useful during construction, such as structure locations, grade crossings, etc. Two bench marks must be established adjacent to structures; one in each side.

All work involved in setting bench marks shall be done with the self-levelling level, when temperature conditions permit. These levels can be procured through the Area Survey Supervisor from the Supply Room at the John O. Morton Office Building.

Bench marks shall be established on some permanent object outside of construction limits and should be accessible for construction purposes. Horizontal spikes in trees and utility poles will not be used. Vertical spikes with washers in roots of trees in wooded areas can be utilized. Trees in inhabited areas must not be scarred in any way. Bench marks shall be numbered to agree with the number of the full station preceding it. The description of the bench mark, stating actual station and offset distance, should be complete and accurate. A descriptive stake may be nailed to bench mark trees in wooded areas, (see Plate No. 55). Turning points, or T.P.'s, should be established on a firm and

distinct point for accurate work. T.P.'s must be numbered consecutively from the point of beginning starting with Number 1. They also should be briefly referenced.

Starting and ending where possible, with a permanent bench mark of known elevation, a double-rodded bench line is run throughout the project with accuracy consistent to third order levelling, which is $0.05\sqrt{M}$, where M equals the length of the level run in miles.

Where there is no permanent bench mark at the end of the project, to accomplish an accuracy evaluation, the double-rodded run will suffice in most cases. An acceptable bench line run should then be adjusted as shown on Plate Nos. 24 and 25.

No equations shall be put in a line of levels, except as explained below.

If this is not possible, and check levels prove that the discrepancy lies in the elevations of the two control bench marks used, then an equation may be made at the bench mark where the levels are closed out.

Precautions necessary to assure accurate bench mark levels include:

1. Balanced backsights and foresights.
2. Maximum sight of 250' instrument to rod.
3. The level rod must be of correct length and graduation - check it with a steel chain for absolute length.

4. Always lightly tap the self-levelling level before reading, observing that the prism is "floating" properly as shown by a "float" of several hundredths above and below the final reading as the level stabilizes.

220 TOPOGRAPHY

Topography, commonly referred to as detail, is generally taken after the completion of the pegging of the center line and the running of the bench line. Detail includes any and all physical features, above or below ground, adjacent to the proposed center line, as well as some features that are distant, but which will influence the proper design of the project. See Plate Nos. 56-59, incl. for standard symbols.

Following are the various methods of recording topography notes in the order of preference adopted by this Department: (See Plate Nos. 26-30, incl.).

1. Station and offset.
2. Swing ties (two ties to each reference point shown).
3. Angle and taped distance.
4. Stadia.
5. Two angles and base line distance on center line.

Dimensions, wherever applicable, must be shown in its entirety. Descriptive notes should be applied to all buildings, such as 1 $\frac{1}{2}$ story house, wooden; commercial garage, brick, etc.

Wells and springs (water) will show diameter, depth, type of lining, depth of water, and date.

Information on isolated trees, 2.5 feet in circumference and over, will show circumference of trunk four (4) feet above ground level, and type. Stumps will show circumference. Ornamental trees, regardless of size, will show circumference and type.

Whenever the proposed project is adjacent to a stream, a list covering five miles downstream of the various factories or facilities using water from the stream will be recorded in the notes. This information is needed as part of the ecology study.

Locate all private septic systems within normal survey area to include approximate size of tanks and fields.

Government bench marks or triangulation stations that require moving must be accurately referenced to center line, and pencil rubbings submitted to the office of the Location Engineer. (Rubbings may be made by placing a thin sheet of paper over the disc and rubbing lightly with a pencil). A facsimile drawing shall be made if a rubbing is impossible.

All historical markers will be located and recorded along with an exact wording of any inscription(s).

Whenever a proposed location is adjacent to an airport the following data must be secured in order to determine the glide angle:

1. The distance from the end of the runway to the proposed center line.
2. The elevation of the end of the runway.
3. Width of the landing area and runway.
4. The airport boundary adjacent to the project.

When surveys are made under winter conditions, notations should be appropriately entered in the book indicating what survey data, including cross sections, should be retaken or checked under bare ground conditions.

220.1 INTERSECTING ROADS AND STREETS

All intersecting roads should be run out at least five-hundred (500) feet from the survey center line and in cases of possible major alignment or grade changes they should be extended to one thousand (1,000) feet or more, depending upon the nature of the possible changes. Complete survey information should be obtained for the full length of the connection, i.e., topography, property lines, property owners, center line levels, cross sections, etc. Where a large skew angle is encountered, consideration should be given to a relocation at a more desirable intersecting angle, and information taken accordingly.

Where important primary road intersections are encountered and interchanges are anticipated, a large area must be gridded and all topography obtained. In such cases specific instructions will be given by supervisory personnel.

At highly developed private roads and entrances alignment, topography, and levels will be taken for approximately two-hundred (200) feet. At other entrances, show pluses on each edge and the range or angle of intersection. In both cases show all pertinent information concerning surfacing, drainage, etc., so provisions can be made for replacing anything disturbed by the proposed construction.

Plate Nos. 28 and 31 show suggested methods of showing intersecting streets, roads or railroads.

Notes regarding intersecting roads and streets, or any intersecting traverse lines, should show the angle of intersection, and the direction of stationing of each line.

When intersection of curves is encountered, the tangents as well as the curves will be related by angles, stations and distances as shown on Plate No. 10.

220.2 METHODS USED TO TIE IN PROPERTY LINES, TREE LINES, ETC.

Usually the survey crew working on a preliminary survey does not know where the existing right of way lines or property lines are in relation to the proposed highway center line. Therefore, every tree line, stone wall or iron pin found adjacent to the highway is treated as though it is or might be a property line.

A line of trees or a woods line running approximately parallel to the highway is located by a plus and offset at every 50-foot station. The beginning, ending and any changes in direction of the woods or trees are located by an "odd" plus and offset. If there is a clear break or line back away from the highway, the direction would be shown by a range line intersecting the proposed highway center line or if the angle is flat enough, additional plus and offsets at right angles to the center line would be taken.

Stone walls, fences or a row of bushes could be a property line. A corner is located by plus and offset at right angles to the proposed center line and a range line is taken to show the direction

in which the line runs. Usually the center of the stone wall or row of bushes is assumed to be the property line. A width of the wall and row of bushes should be taken.

The above measurements would be made with a cloth tape and read to the nearest foot.

Any iron pins or stone monuments found are tied by swing ties from the center line using a steel chain and reading to one hundredths of a foot, or by angle and distance from line, using transit and steel chain. The exact location is very important.

220.3 UTILITIES

The name and address of every utility having installations in the area being surveyed shall be listed in the front of the topography book.

Utilities located above ground - power, telephone and telegraph poles, hydrants, etc., should be located by prism or instrument, plus and offset, swing ties, or angle and distance; all dimensions given to tenths of a foot. Always show the utility Company identification and numbers (if any) which are on the pole. When poles are in joint usage, the owning utility is listed first, for example - a pole used by New England Telephone, but owned by Public Service Company:

PSCO
27

NET
34

Pole numbering for the different utilities may differ, and may increase in opposite directions.

Offsets should be taken to the center of hydrants, manholes, etc. The offset to trees and poles will be taken to the face.

Utility lines crossing the proposed location should be located for at least 200 feet from center line in each direction, to include at least two poles each side that will not normally be affected by construction. If an angle point in the utility line occurs within two poles beyond this distance, the angle point and direction and degree of angle should be located. Running a spur traverse along the pole line is a convenient method. Poles with guys should be noted "guy." Heavy guying, such as on transmission poles, should be located at the point of entry into the ground.

Underground utilities (sewer, gas, water, power, telephone, and petroleum pipe lines) are best located by personnel of the respective utility. The Party Chief should contact the local office of the respective utility, identify himself, and make an appointment at a mutually convenient day and time to meet representatives of the utility who will show him the location of the facility by "M-scope" or other method. The Party Chief should advise the utility as to the extent of the information desired so the representative will have the proper information with him in the field. Usually two days notice will enable the utility company to schedule their personnel for this location work.

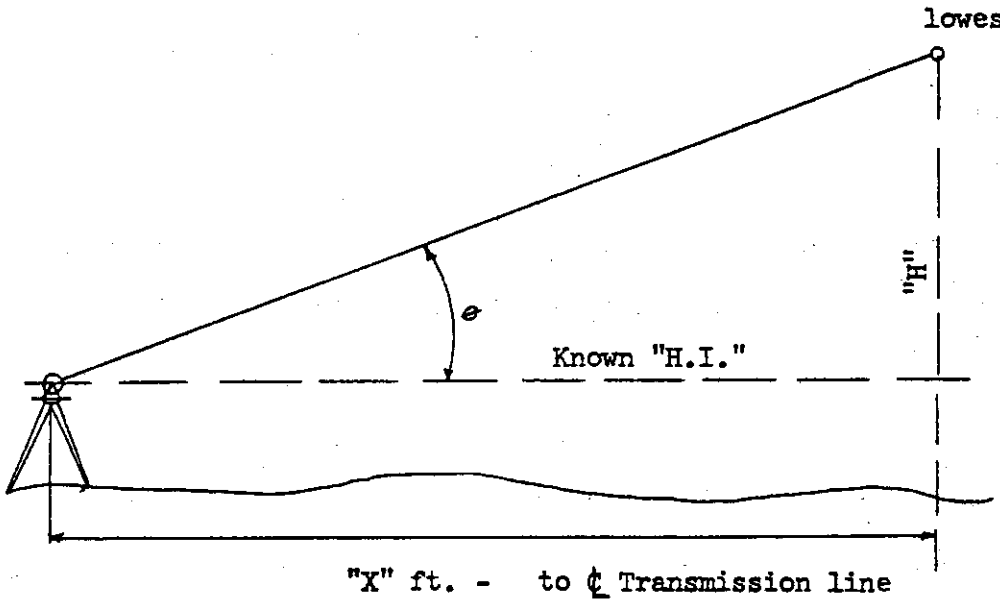
The preferred procedure in locating underground utility locations is for the survey crew to proceed with the utility representative to paint or stake the location, then to tie in this location to center

line or traverse lines. This will cause a minimum of delay for all concerned, and the utility representative will not be required to wait while the note keeper sketches in the location.

Manhole covers should be removed and invert elevation and pipe size noted so far as possible, as noted in the section on "Cross-Sections."

In urban areas it is advisable to set up a separate page(s) for underground utilities showing only line stationing and utility locations. (See Plate No. 30).

Any overhead major utility line - other than service lines to individual buildings - which crosses the proposed location shall be located and the elevation of the wire where it crosses the center line shall be determined. The following method is useful for determining the elevation of overhead utility installations at any point: set up a point a known distance from the center line of the utility; determine the H.I. of the instrument, turn the vertical angle to the wire(s); compute the vertical distance trigonometrically. A range finder is also available for this purpose and may be obtained through the Survey Supervisor.



"X" ft. - to ℄ Transmission line

"H" = X tan θ

"H" + "H.I." = Elev. of wire

If elevation determined is the lowest of several wires, note this, and how many wires are installed.

If more than one transmission line is located along the same right of way, the elevation and location should be determined for each line.

Auxiliary traverses will be established for the purpose of locating topographic and cultural details, or for the purpose of closing survey lines by generally accepted methods. (See Plate Nos. 22 and 23).

222.1 TRAVERSE LINE FOR CLOSURE

The closure traverse is run from north to south or east to west, (opposite direction of center line stationing) primarily to check the accuracy of the center line by coordinate geometry.

The line generally will follow along the existing roadway, with even stations put in at one hundred foot intervals (NOT FLAGGED). Turning of angles and stationing will be done as one operation not as two separate operations. Swing-ties will be established at each P.I. and other intermediate points where necessary and recorded in the field book. Paint only P.I's.

Minimum detail is taken from this line to show municipal buildings, churches, structures, existing roadway, and any other similar prominent items.

The error of closure of the traverse and center line, after the distribution of any angular error, will not exceed 1:10,000 on urban and compact projects, or 1:5,000 on all other projects. There may be special exceptions to this rule, but only if they are sanctioned by the Location Engineer. (See Plate No. 60).

222.2 TRAVERSE LINE SURVEYS

The traverse survey is the basic control, in many cases, for the future location of the highway center line and must be carefully and accurately run. Generally the traverse line will run along the existing roadway in the opposite direction of the anticipated center line, as it may be utilized as a closure check at a later date.

The area to be surveyed will be noted on a plan accompanied by a detailed survey request.

The traverse will be stationed at regular 50-foot intervals with unflagged stubbies to facilitate the taking of detail and any cross sections which are requested. If cross sections are not requested, a profile will generally be taken. Only P.I's. to be painted.

Upon completion of the survey, the data will be submitted to the Highway Design Office through the Location Engineer. After the plotting is complete a center line will be chosen and the survey crew asked to make a complete survey about it.

224 BRIDGE SURVEYS

Where stream, road, railroad, etc., crossings necessitate a structure certain information must be accurately obtained to enable engineers to adequately design a structure to fit the conditions.

The following information will be taken from the center line or traverse:

1. A grid of the stream, road or railroad. See Plate No. 44.

2. Cross sections outside of the grid coverage, normally taken for the approaches.
3. At stream crossings, outside of the grid coverage, locate and determine the elevation of the stream bed, also top and bottom of stream bank, to a distance of 300 feet from the proposed center line.
4. Locate all ledge outcrops, abandoned piers and abutments, and large boulders.
5. Obtain complete topography, above and below ground.
6. Record approximate location, type and size of nearest structure upstream and downstream.
7. Fill out the Standard Bridge Report Form.
8. Note any other information which may be beneficial to the designers.

When the terrain and topography allow numbers 3, 4, and 5, of the above requests, can be taken by stadia from the center line or any other established point. If this method does not appear appropriate for the situation a traverse can be run along the edge of the stream, and the required information taken from it as shown on Plate No. 29.

Sections may be taken from this traverse, in addition to the required grid, and all elevations will be related to U.S.C. & G.S. or U.S.G.S. datum.

When the survey line crosses, or is near an existing structure, locate the corners of the abutments, ends of retaining walls and record their batter. Locate the outside face of all curbing, all angle and

end points on wing walls, plus any other measurements or information that would be beneficial to properly design the structure. Use steel tape measurements and transit angles to locate all points. Elevations will be taken at all points.

Special in depth surveys may be requested, by the Bridge Division, to determine any lateral or vertical movement of an existing structure. This survey will usually involve complete detail of the structure, horizontally and vertically. Detailed instructions will be furnished to the Party Chief on each project.

Covered Bridge checks are performed periodically as requested by the Bridge Design Division for the purpose of determining their safety. Profiles are taken on a previously established center line; horizontal distances are measured from the center line to the plank arches or trusses to determine any lateral variations.

225 RAILROAD CROSSINGS

Where proposed highways are to cross railroad trackage, contemplating either a grade crossing or a structure, certain specific information relating to the track alignment and elevations are required.

The procedure adopted by this Department is geometrically simple and produces the required information. Utilizing the gauge line (inside of rail) of one rail, and beginning at its intersection with the proposed center line, lay off 50-foot stations along the inside of the rail, whether curve or tangent, increasing in one direction and decreasing

the other, from a station of greater value like 20+00.00 or 30+00.00. The stations may be identified with a sharp crayon or other suitable marker along the inside of rail. The distances must be measured with accuracy and the marks definite. When this has been established, the transit is set up at the above mentioned intersection point and the angle of intersection measured (four readings). The same general procedure is followed when trackage is on curve, however deflections from station to station of trackage properly correlated to the proposed highway center line are taken and recorded appropriately. Profiles of each rail, along and opposite established stations, will then be taken. This procedure should be accomplished to each set of tracks when there is more than one set at the same location. The extent of survey each side of crossing should be a minimum of 500 feet. See Plate No. 31.

When reconstruction is contemplated at existing railroad crossings the type of material, such as wooden plank, asphaltic concrete, or whatever used for the crossing, should be shown, as well as the dimensions - length and thickness. In addition, the type and length of pavement retainer, if other than the plank, adjacent to the rails should be shown.

226 CHANNEL CHANGES

Extensive channel change surveys are sometimes required to conform with highway relocation proposals. Information regarding high and low water conditions, existing retaining walls, area drainage

patterns, adjacent facilities using water from stream and its purpose, and any other existing conditions or items that in some way have a direct bearing on the proposal, ecologically or otherwise, must be obtained.

Generally a base line survey, tied into any highway alignment, proposed or existing, would be most practical. Sections at 50-foot intervals, or less where required, will be taken from a left to right progression along the base line at distances that will produce sufficient vertical information. In addition, profiles, upstream and downstream beyond the limits of the sections will be taken to a distance of 300 - 500 feet in order to establish the proper gradient for the channel change. Sections should include all of the existing section of the stream to be eliminated in order to design changes and to compute resultant quantities.

227 LAND SURVEYS

At times a complete property survey, plus a plan, is required to be made by the Survey Section. These are to conform with current regulations as established by law, and the code of ethics as adopted by the New Hampshire Land Surveyors Association.

228 SURVEYS FOR SPECIAL PURPOSES

In addition to surveys for highway projects, the Department, from time to time, is obligated to make surveys for other agencies within the State, ordinarily done through the Special Services Division of this Department.

228.1 HYDROGRAPHIC SURVEYS

1. In waters not affected by tides, the usual objective of the survey is to ascertain water volume or the underwater contour features. This is accomplished by conventional methods: vertical data by grid or stadia method; horizontal data by grid station and offset or stadia.

2. In tidal streams, adjacent to existing structures where erosion exists, periodic evaluations are made to determine any subsequent changes caused by erosion. This is accomplished by taking profiles along previously established guide lines so that the information can be plotted, superimposed. A fathometer is generally used for vertical data.

3. In tidal waters where dredging, construction of marinas, docks, piers, seawalls, groins, jetties, reclamation, etc., are to be accomplished, procedures for surveys can be simple or complicated depending upon the nature of the project. Under simple operations the conventional methods explained above can be utilized - under extensive operations, it will be necessary to establish an accurate base line net utilizing multi-instrument procedures in conjunction with a sounding vessel or vessels.

228.2 SKI AREAS, PUBLIC INSTITUTIONAL FACILITIES, AND PARKS

1. In developing ski areas conventional methods to obtain horizontal and vertical data are utilized.

2. Preliminary survey data required for the design and construction of many public institutional buildings and State Parks, is accomplished by conventional methods.

229 BORING LAYOUTS

The responsibility of locating boring points, with elevations, on many structure sites is delegated to the Survey Section.

The location of these points must be accurately layed out as described on bridge boring plans which accompany each request. A steel tape to be used for these measurements, guided by transit measured angles and alignment. Ground elevations at each point, read to the nearest tenth, and marked on each reference stake. In some cases, it may be impractical to place stakes at the exact location of the boring, therefore it may be necessary to so place other stakes that give direction and offset information to these points.

The looseleaf field notes, to be returned with boring layout plans after completion of layout, will be complete as to descriptions, computations, project number, date, weather, names of crew members, etc. See Plate No. 33.

230 CROSS SECTIONS

Cross section levels provide the necessary information with which to compute earthwork, design gradients, design drainage structures, and to compute final quantities of work done on highway projects.

Levels will be accomplished with an Engineer's level, reading all turns to the nearest 0.01 of a foot. The maximum tolerance of error between bench marks will be 0.04 of a foot. A rerun will be required when this is exceeded.

Rod readings to the nearest 0.1 of a foot will be taken on the following items and any other items in the same classification: ground shots, pavement other than concrete, top of catch basins, and manholes, inlet and outlet flow lines of pipes or small drainage structures, underground utilities where obtainable, top and bottom of wells, garage or other storage facility floors, water course profiles, cellar floors where required, bottom step and top step of all steps other than concrete.

Rod readings to the nearest 0.01 of a foot will be taken on the following: concrete pavement, sills of any building, railroad tracks, concrete steps, concrete sidewalks, concrete curbing, etc.

230.1 CROSS SECTION PROCEDURE

It is imperative that the Chief of Party thoroughly instruct the other members of the crew the method and the purpose for taking cross sections.

Prior to the taking of the sections, care should be exercised in establishing section lines with a transit or a right angle prism, depending upon the terrain and other conditions. In thick brush areas it may be necessary to do some cutting, however this must be held to an absolute minimum. Radial lines within curve areas will be used for sections. When establishing section lines, it is of the utmost importance to identify the direction with formidable "risers," either cut saplings or other suitable material, placed accurately and at maximum distances

from the center line. When properly done at this stage, these "risers" become very valuable throughout all subsequent phases of operations, including finals. To use any inferior quality of "riser" material is sheer wasting of time and money.

Sections are to be taken at least every 50 feet and at intermediate points necessary to provide accurate earthwork quantities, or to show salient physical features necessary for proper design. Offset distances will be cloth taped accurately, using every precaution necessary, to the nearest foot excepting offset distances to existing items of construction or items of equal importance, which will be to the nearest 0.1 of a foot. The extent of the section is dictated by the classification of the project as well as the character of the terrain. This factor will be discussed by the Chief of Party and the Area Survey Supervisor at the beginning of the survey.

Turning points should be well described, including station and offset so that they may be recovered for checking purposes.

Locke levels may be used to extend sections reasonable distances from the center line by individuals adequately trained in the use of such instruments.

So-called "half" sections will not be taken when they are to be used for quantity purposes - half sections can and should be taken on drives, sidewalks and the alike.

So-called "plus-shots" (above the H.I.) will not be taken - Locke level or a turn down or up with level must be accomplished.

The abbreviations, where applicable, shown on Plate Nos. 69 - 70, incl, will be utilized with section notes to the fullest extent. Give as much descriptive information as possible over section notes.

Skew sections along water courses will be taken for proper drainage design.

Three spaces will be left between sections of one station to sections of the next station; two spaces between lines of sections on the same station.

232 DEGREE OF ACCURACY AND COVERAGE

Since the magnitude and the requirements of the design criteria vary proportionately, generally speaking, with the classification of the highway involved, the degree of accuracy and the extent of survey coverage varies accordingly.

232.1 INTERSTATE AND PRIMARY ROADS - CLASS I

In accordance with paragraph 232, this classification demands the highest caliber and the most extensive of all highway surveys, accomplished by conventional methods. The following guides will be respected fully:

1.	Error of closure in position, suburban and rural	1/5,000
2.	Error of closure in position, urban	1/10,000
3.	Error of closure, vertical (third order)	
	M = distance in miles	0.05 ft.$\sqrt{M}$
4.	Detail - Min. distance from ℄ barrel	200 ft.

5.	Sections - Min. distance from ℄ barrel	150 ft.
6.	Extent of complete survey on side streets	1,000 ft. (Primary) 1,500 ft. (Interstate)
	a. Detail - Min. distance from center of street	100 ft.
	b. Sections - Min. distance from center of street	100 ft.
7.	Intersection - Grid coverage, min. (25 or 50-foot intervals)	200 ft. sq.
8.	Interchange - Grid coverage, min. (Limits will be indicated on survey request) (25 or 50-foot intervals)	Variable

(Note: Items 4 thru 8 are to be used as a guide and are subject to change under certain conditions).

232.2 SECONDARY ROADS - CLASS II

1.	Error of closure in position, suburban and rural	1/5,000
2.	Error of closure in position, urban	1/10,000
3.	Error of closure, vertical third order	0.05 ft. $\sqrt{M}$
4.	Detail - Min. distance from	150 ft.
5.	Sections - Min. distance from	100 ft.
6.	Extent of complete survey on side streets	1,000 ft.
7.	Intersection - w/grade separation - Grid (25 or 50-foot intervals)	200 ft. min.
8.	Interchange - None	

(Note: Items 4 thru 8 are to be used as a guide and are subject to change under certain conditions).

232.3 RECREATIONAL AREA ROADS - CLASS III

General Procedure same as Class II Roads

232.4 URBAN OR COMPACT AREA ROADS - CLASS IV

General procedure same as Class I Roads excepting lateral coverage not as extensive; each project given separate and special consideration and the extent of survey be adequate to fulfill the needs. Error of closure in position will be at least 1/10,000.

232.5 TOWN ROADS - CLASS V

In most cases, these surveys require a minimum of information to meet the design criteria of low traffic highways. In these cases all that is required usually is a center line, profile, detail consisting of traveled way, woods line, walls, existing drainage, property lines, fronts of buildings, and sections where it is necessary to take land beyond existing right of way.

There could be some projects that would require more total refinement in which case they would be treated accordingly.

232.6 BETTERMENT TYPE SURVEYS

In general this type survey will apply to work performed by Highway Department Division Forces, where no payment of final quantities are involved, little or no additional land taken, or on projects where resurfacing and widening of the present road are contemplated, within the legal right of way. Where the present legal right of way is of sufficient

width to accommodate the new construction, the center line and profile along the proposed construction, with typical cross sections at driveways and intersecting roads or other controls, will be all that will be required.

The Division Engineer and the Location Engineer should make a preliminary inspection of the roadway site, taking into consideration the legal right of way and determine the various control points as well as any modifications or revisions in alignment or grade which is deemed advisable.

The alignment of the existing roadway should be generally followed with such modifications which will tend to reduce hazardous alignment, sight distance and grade, and reduce costs of construction by shortening the distance or decreasing grading quantities. Particular care must be used in fixing the center line on sections where the existing roadway is narrow in order to establish the line, so as to obtain the best results with the least amount of grading; this being very essential on steep hillside locations.

When heavier cuts and fills are necessary and the limits of slopes fall outside the right of way or when a shift in alignment is deemed advisable, a survey of sufficient refinement should be made to obtain enough data for the preparation of right of way plans to secure the necessary width. This taking can also be done by easements.

Upon completion of the survey all of the data will be forwarded to the Division Office for plotting by the transitman-draftsman.

235 DETERMINATION OF AZIMUTH

POLARIS OBSERVATIONS

To determine the true bearing of a line from an observation of "Polaris," the surveyor should read the following information and examples carefully and acquaint himself with the time relationships, Constellation Charts, and Ephemeris tables.

Special equipment for a "Polaris" observation should include two flashlights, transit with a Solar Attachment (telescopic reflector not required, but is helpful), U.S.G.S. Quadrangle Maps, and a copy of current Ephemeris tables. One transit with a Solar attachment is available at the stock room in the Highway Design Division. Gurley Ephemeris tables are recommended and were used entirely for the examples shown in this manual. Ephemeris tables of makes other than Gurley are often similar but not identical.

There are three specified times for observing "Polaris": (1) Observation at "Culminations," (2) Observation at "Elongations," and (3) Observation at "Any Hour Angle," however, the field work will be the same for all three and should be done in the following manner:

Establish a base line from 300 to 500 feet in length, laid out in a general northerly direction and having good vertical clearance. The southern end of this base line is the point of observation and is the point where the transit is positioned. Then with the use of two flashlights, horizontal angles may be turned. One flashlight is used to illuminate the transit and the other flashlight is held back of a white piece of

paper which is held in back of the plumb bob string at the northern end of the base line. The Latitude and Longitude of the point of observation may be determined by scaling them from a U.S.G.S. Quadrangle Map. In turning horizontal angles in the field, always turn the azimuth angle clockwise, repeat this four times, and determine its mean.

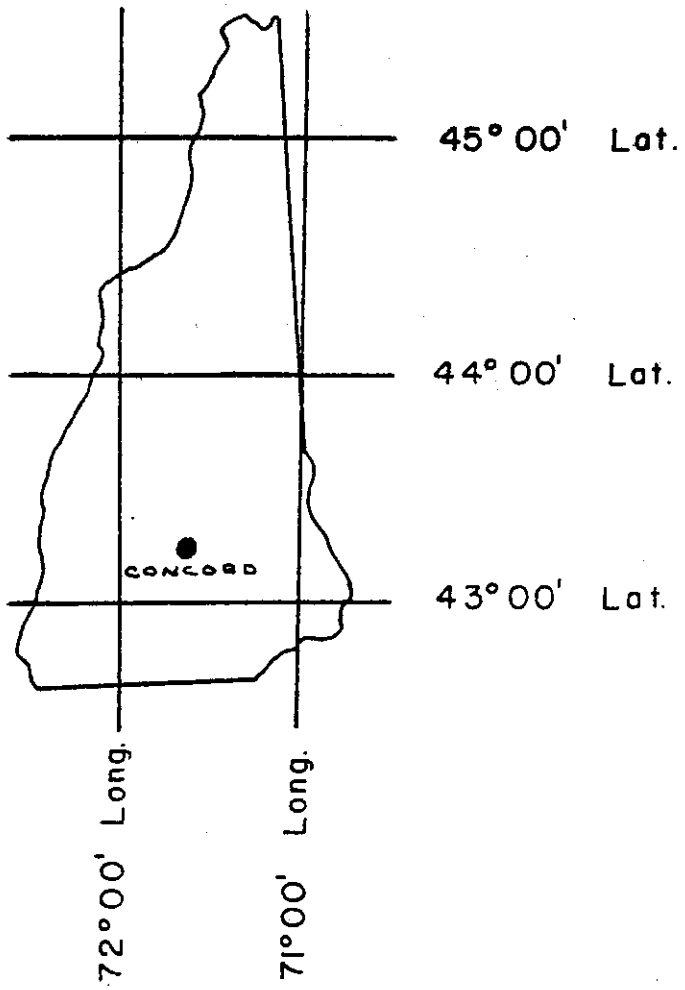
For computations of the three types of "Polaris" observations prior to and after the field work, see examples No. 1, 2, and 3.

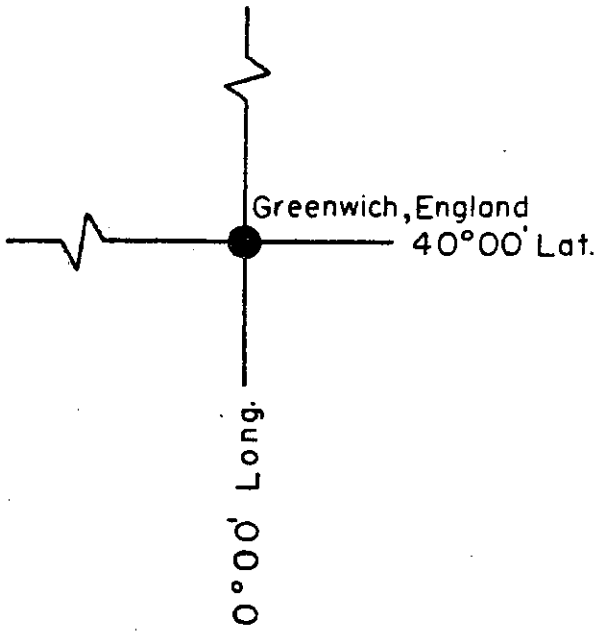
"Polaris," the North Star which forms the end of the handle of the "Little Dipper," is the star usually used for surveying purposes. This star revolves, counter-clockwise, about the North Pole in a small circle whose radius (Polar Distance) is about 52 minutes and whose declination is its angular distance north of the Equator. When the star is directly above the pole, it is in the plane of the meridian (bearing true north) and is said to be at "Upper Culmination." About 12 hours later, this star will be directly below the pole (bearing true north) at "Lower Culmination." About half-way between these two positions, this star reaches its greatest east or west bearing, and at such times is said to be at its greatest elongation. These positions are known as the "Eastern Elongation" and the "Western Elongation." See Constellation Charts, Page 45 through Page 48 of this manual. Polaris observations may be taken at either of the culminations or elongations, as well as at any desired time that the surveyor may wish to use; however, since the field work consists of taking simultaneous readings of the horizontal angle (azimuth angles taken clockwise) it is apparent that more accurate results will be obtained if the work is done when the North Star is at

either "Elongation." At these times, the horizontal angle will not vary more than 30 seconds of arc in 30 minutes of time and it is therefore not essential that time be known more accurately than 10 minutes. On the other hand, if Polaris observations are made at one of the "Culminations," the horizontal angle will vary at the rate of one minute of arc in three minutes of time and it is essential that time be known to the nearest minute. In general, all preparatory field work necessary to taking Polaris observations should be arranged beforehand, so that the measuring and recording of Polaris angles may be done as quickly as possible.

235.1 RELATIVE POSITIONS OF NEW HAMPSHIRE AND GREENWICH, ENGLAND

(Not to scale)

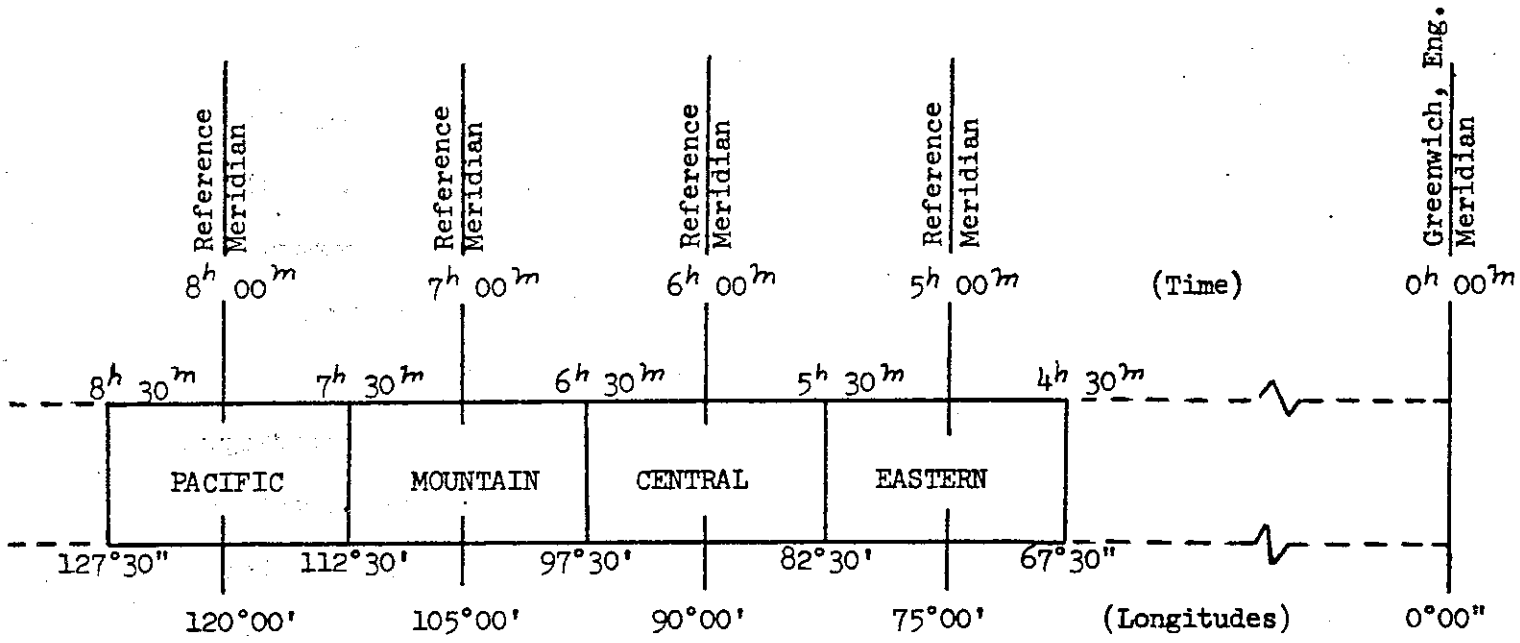




235.2

TIME RELATIONSHIPS

ZONES OF STANDARD TIME IN THE UNITED STATES



1 Degree of Arc in Longitude = 4 Minutes of Time
1 Minute of Arc in Longitude = 4 Seconds of Time
1 Second of Arc in Longitude = 1/15 Seconds of Time

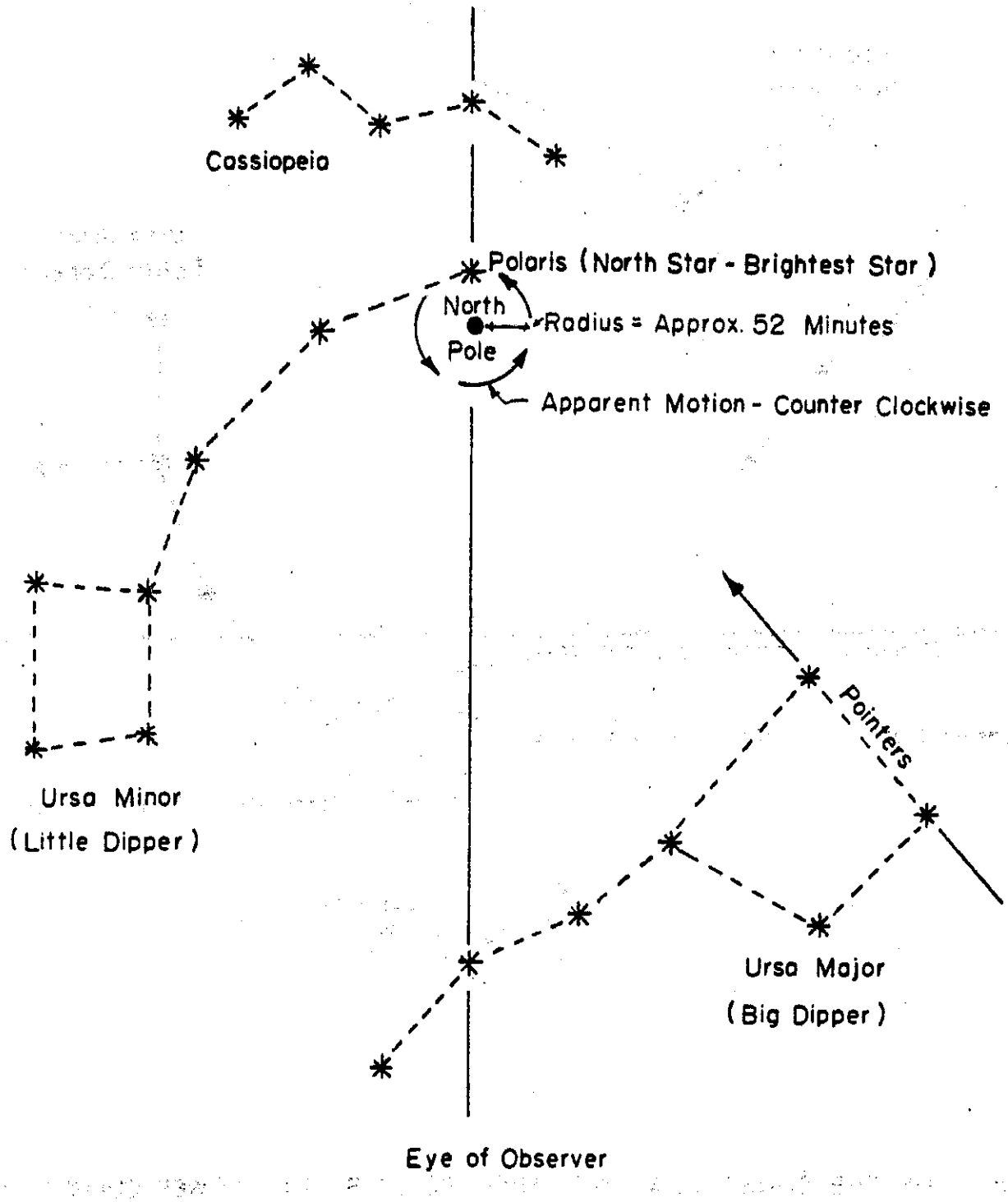
1 Hour of Time = 15 Degrees of Arc
1 Minute of Time = 15 Minutes of Arc
1 Second of Time = 15 Seconds of Arc

For Conversions of Arc to Time and Time to Decimal Parts,
see Conversion Tables in Ephemeris Manuals.

Example: $71°31'30"$ of Arc in Longitude = $4^h\ 46^m\ 06^s$ of Time
and $4^h\ 46^m\ 06^s$ = 4.768 hours = 0.1987 days

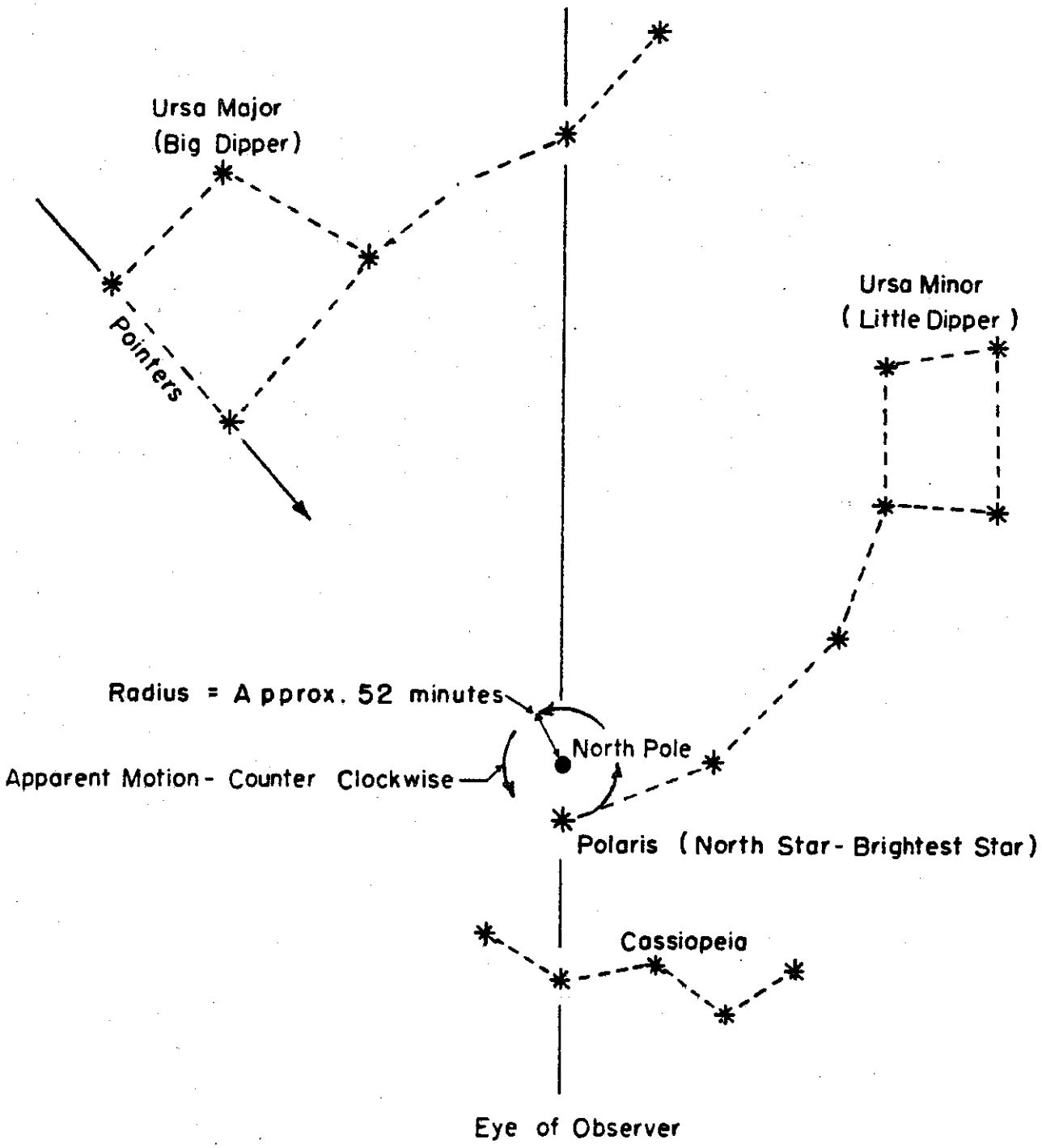
Standard Time is the Mean Solar Time of a Standard Meridian, legally adopted and, in general, used over the area or zone nearest to the Meridian. Standard Meridians, beginning at Greenwich, England, are established each 15° of Longitude around the globe. The time of each Standard Meridian, and the zone which it determines, differs by exactly one hour in time from that of adjacent zones. New Hampshire lies in the Eastern Time Zone and is entirely east of the 75th Meridian. A moment of time is given by the year, the day of the month, and the elapsed time since midnight (0^h) at the beginning of the day named. It must be further defined by the Meridian from which it is reckoned. Accordingly, "Greenwich Civil Time" (G.C.T.) is civil time reckoned from the moment of midnight at the Greenwich Meridian; and 75th Meridian Time (Eastern Standard Time, E.S.T.), for example, is civil time reckoned from midnight at the 75th Meridian. "Local Civil Time" (L.C.T.) is civil time reckoned from the precise Meridian of Longitude where an observation is taken.

Example: Longitude = 71°31'30" and Eastern Standard Time (at the Time of Observation) was found to be $9^h\ 24^m\ 30^s$ p.m.
75th Meridian - Meridian at Observation = 75°00'00" - 71°31'30" = 3°28'30."
3°28'30" of Arc = $0^h\ 13^m\ 54^s$ of time. Since the observed time is p.m., 12 hours is added to $9^h\ 24^m\ 30^s = 21^h\ 24^m\ 30^s$, and since all New Hampshire Observations are East of the 75th Meridian, $0^h\ 13^m\ 54^s$ will be added to the E.S.T. for the 75th Meridian. Therefore, Local Civil Time = $21^h\ 24^m\ 30^s + 0^h\ 13^m\ 54^s = 21^h\ 38^m\ 24^s$.

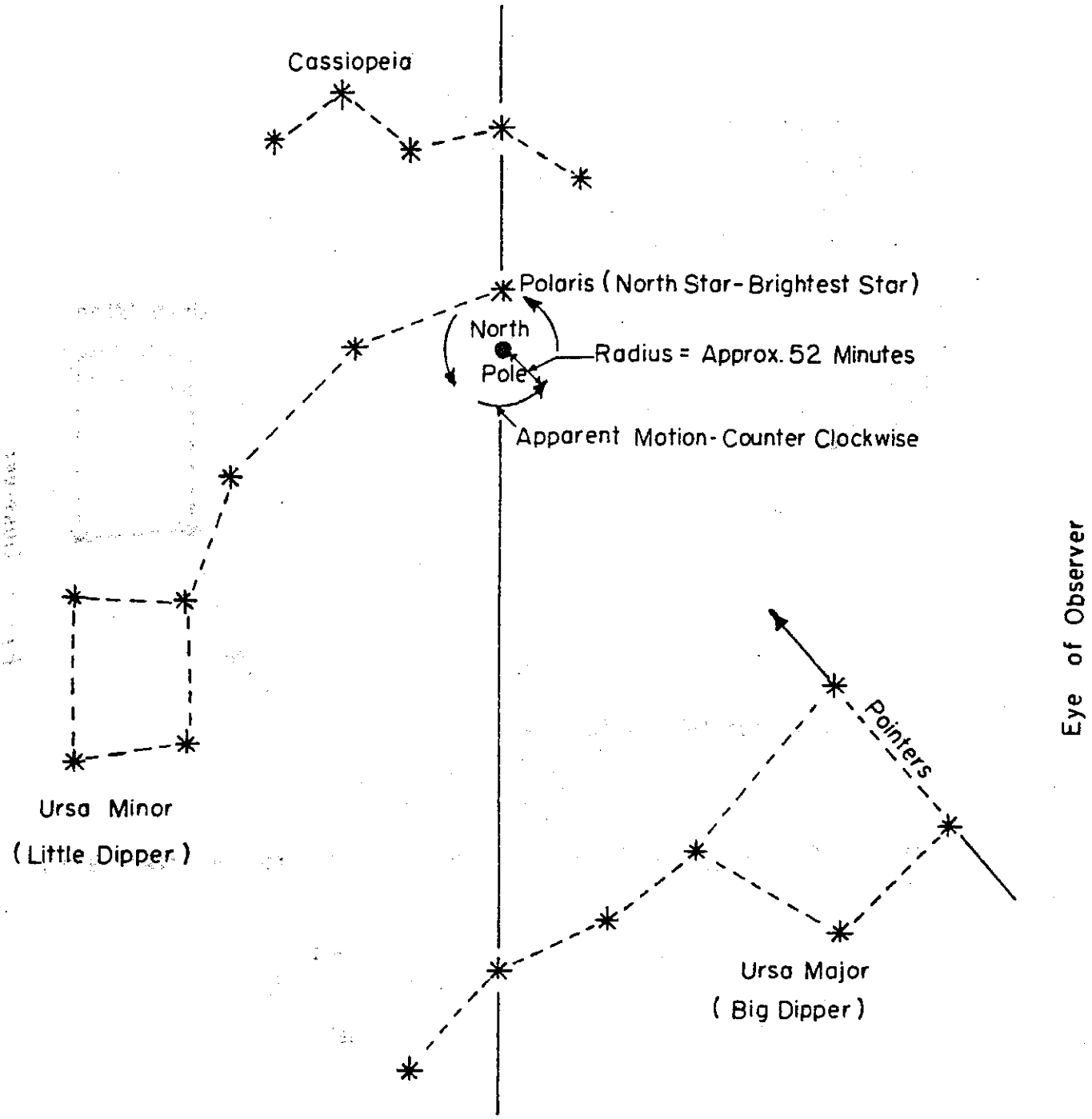


POSITION OF THE CONSTELLATIONS WHEN POLARIS IS AT UPPER CULMINATION

235.4 CONSTELLATION CHART No. 2

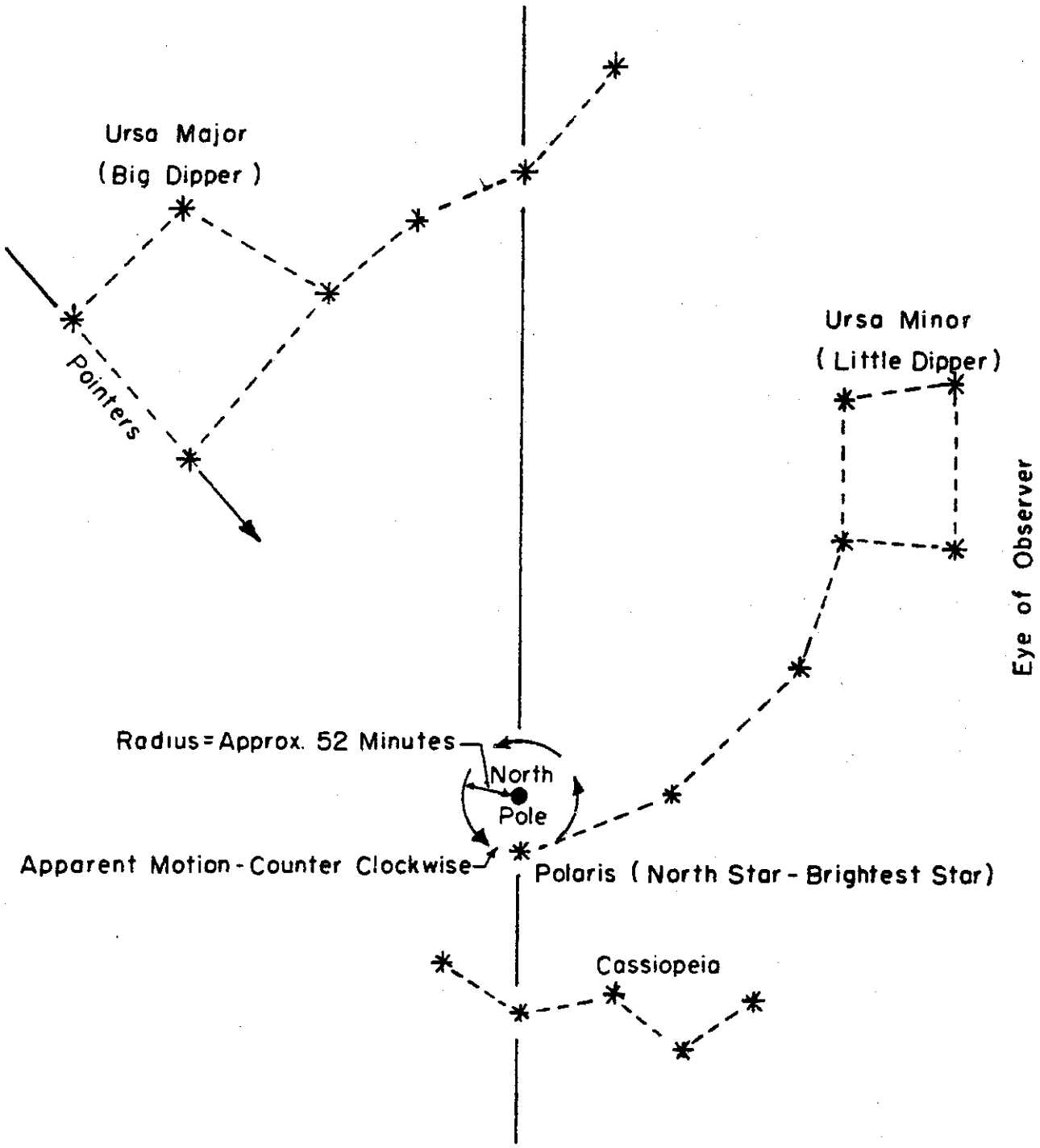


POSITIONS OF THE CONSTELLATIONS WHEN POLARIS IS AT LOWER CULMINATION



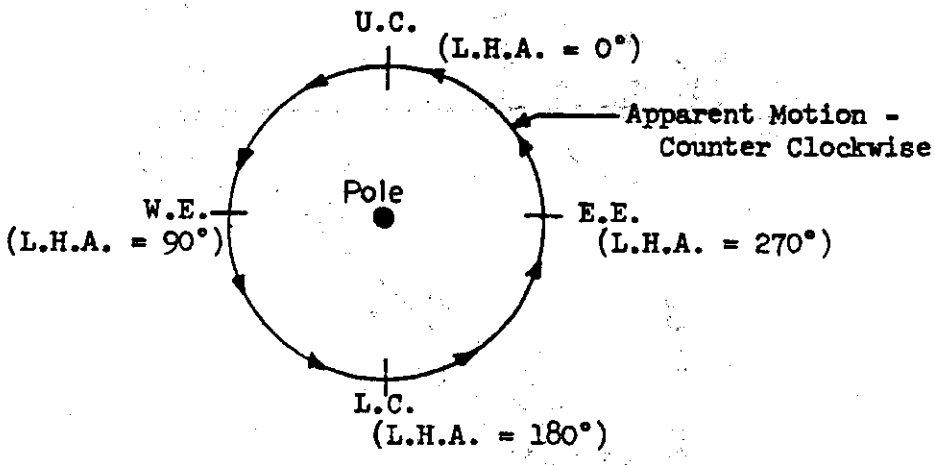
POSITION OF THE CONSTELLATIONS WHEN POLARIS IS AT EASTERN ELONGATION

CONSTELLATION CHART No.4



POSITION OF THE CONSTELLATIONS WHEN POLARIS IS AT WESTERN ELONGATION

235.7 PATH OF POLARIS ABOUT THE NORTH POLE



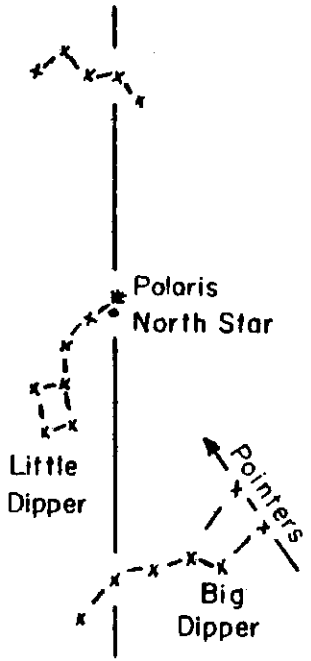
U.C. = Upper Culmination and L.H.A. (Local Hour Angle) = 0°00'

W.E. = Western Elongation and L.H.A. (Local Hour Angle) = 90°00'

L.C. = Lower Culmination and L.H.A. (Local Hour Angle) = 180°00'

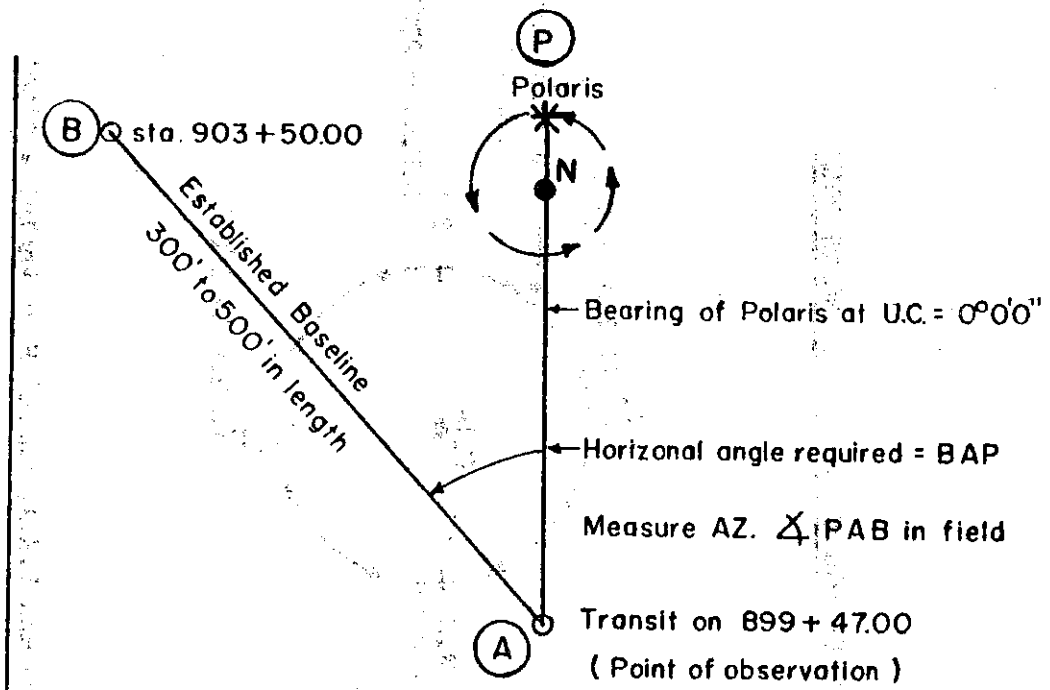
E.E. = Eastern Elongation and L.H.A. (Local Hour Angle) = 270°00'

235.8 Example No.1 POLARIS AT UPPER CULMINATION (U.C.)



POSITION OF CONSTELLATIONS WHEN POLARIS IS AT UPPER CULMINATION

(Approximate locations)



GRAPHIC FIELD POSITION WHEN POLARIS IS AT UPPER CULMINATION

(Approximate locations)

EXAMPLE NO. 1

POLARIS AT UPPER CULMINATION (U.C.)

Meridian by observation on Polaris at Concord Airport on December 9, 1970
Solar Ephemeris Tables for 1970 - Booklet by W. & L. E. Gurley
Latitude: 43°12'30" Longitude: 71°31'30"

Convert Latitude to decimals of a degree: 43°12'30" = 43.208°

Convert Longitude to hours, minutes, and seconds and to decimals of an hour:
75th Meridian to Concord Airport = 75°00'00" - 71°31'30" = 3°28'30" of Arc.
3°28'30" Arc = $0^h\ 13^m\ 54^s$ in Time. Time at the 75th Meridian = $5^h\ 00^m\ 00^s$.
Time at Concord Airport = $5^h\ 00^m\ 00^s - 0^h\ 13^m\ 54^s = 4^h\ 46^m\ 06^s = 4.768^h$.

Civil Time, U. C. @ Greenwich, Eng. (Table for Polaris at U. C.) on Dec. 6, 1970	=	$21^h\ 03^m\ 53.0^s$
Reduction to date for Dec. 9, 1970 (Table for Polaris at U. C.) Variation per day for Dec. 6 = $-3^m\ 56.7^s$ Variation per day for Dec. 16 = $-3^m\ 56.9^s$ Interpolation for Dec. 9 = $0.3 \times 0.2^s = 0.06^s$ = Negligible Use $-3^m\ 56.7^s$ per day x 3 days = $-0^h\ 11^m\ 50.1^s$	=	$-0^h\ 11^m\ 50.1^s$
Civil Time, U. C. @ Greenwich, Eng. on Dec. 9, 1970	=	$20^h\ 52^m\ 02.9^s$
Reduction to Place (Concord Airport) (Table for Polaris at U. C.) Variation per hour: Use -9.86^s, Hour at Concord Airport = 4.768^h Reduction = $4.768^h \times 9.86^s = -0^h\ 00^m\ 47.0^s$	=	$-0^h\ 00^m\ 47.0^s$
Civil Time, U. C. @ Concord Airport on Dec. 9, 1970	=	$20^h\ 51^m\ 15.9^s$
Reduction to Eastern Standard Time @ 75th Meridian 75th Meridian = $5^h\ 00^m\ 00^s$, Concord Airport = $4^h\ 46^m\ 06^s$ Difference = $5^h - 4^h\ 46^m\ 06^s = 0^h\ 13^m\ 54^s$ = Reduction	=	$-0^h\ 13^m\ 54.0^s$
U. C. @ Concord Airport, Eastern Standard Time on Dec. 9, 1970	=	$20^h\ 37^m\ 21.9^s$
Reduction for A.M. or P.M. Time	=	$-12^h\ 00^m\ 00^s$
P.M. Time	=	$8^h\ 37^m\ 21.9^s$

Black C.P.
White ⊼
Green Ch.
Brown ⊥

12-9-70

POLARIS OBSERVATIONS

Cold & Clear 3

	Polaris at upper culmination				
Civil Time u.c.@ Greenwich on Dec. 6, 1970					
Eph. Table for Polaris at u.c. =			$21^h\ 03^m$	53.0^s	
Reduction to date for Dec. 9, 1970					
*Eph. Table for Polaris at u.c. =			$-0^h\ 11^m$	50.1^s	
Civil Time u.c.@ Greenwich on Dec. 9, 1970 =			$20^h\ 52^m$	02.9^s	
Reduction to place (Concord Airport)					
Eph. Table for Polaris at u.c. =			$-0^h\ 00^m$	47.0^s	
Civil Time u.c.@ Concord Airport on Dec. 9, 1970			$20^h\ 51^m$	15.9^s	
Reduction to East Std. Time @ 75° Meridian			$-0^h\ 13^m$	54.0^s	
u.c.@ Concord Airport East Std. Time =			$20^h\ 37^m$	21.9^s	
Reduce to P.M. Time			$-12^h\ 00^m$	00.0^s	
East Std. Time P.M. =			$8^h\ 37^m$	21.9^s	

Watch set from radio for East Std. time and time of observation made at $8^h\ 37^m\ 22^s$ P.M.
∡ on Pt. A, site on Pt. P (North Star) ∡'d Pt. to Pt. B

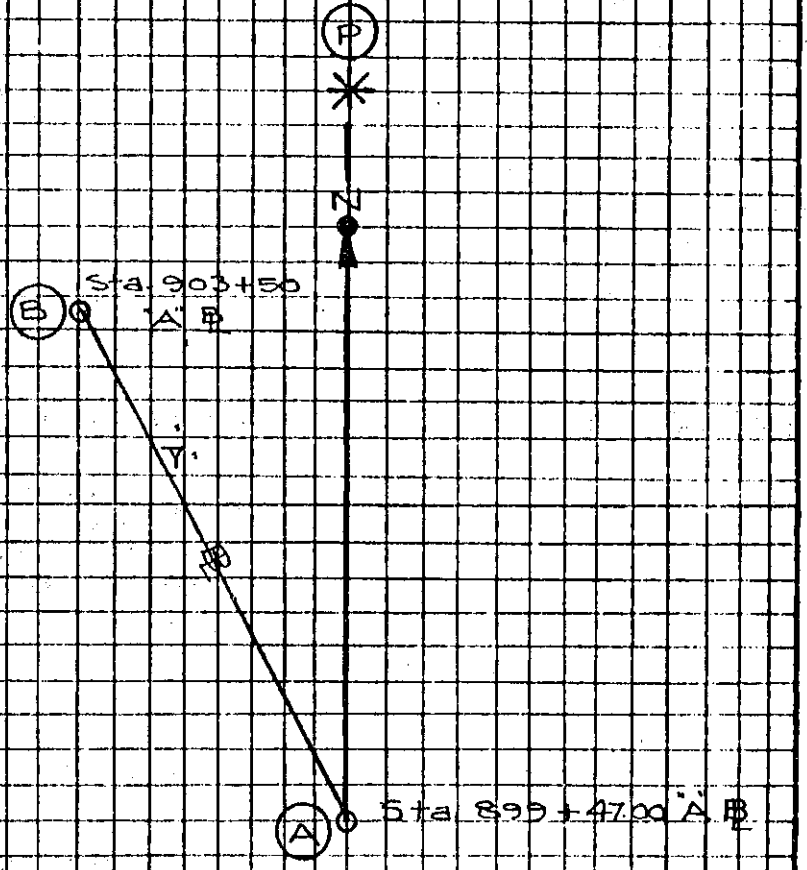
Time Allowed for observations = 4 Minutes

H	M	S	°	′	″
8	35	22	334	27	30
8	36	22	308	55	00
8	37	22	283	22	30
8	38	22	257	50	00

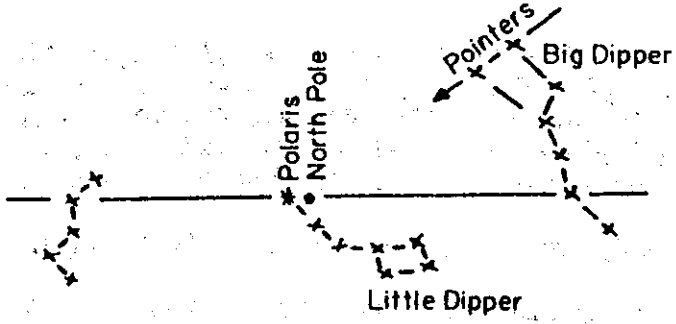
257°-50′-00″ + 1080° ÷ 4 = 334° 27′ 30″
∡ P.A.B. = 334°-27′-30″
∡ B.A.P. = 25°-32′-30″
Bearing AB° N 25°-32′-30″ W

Ephemeris tables for 1970 by W. & L. E. Gurley

Location of Point (A)
Concord Airport
Lat. 43° 12′ 30″ Scaled
Long. 71° 31′ 30″ Scaled

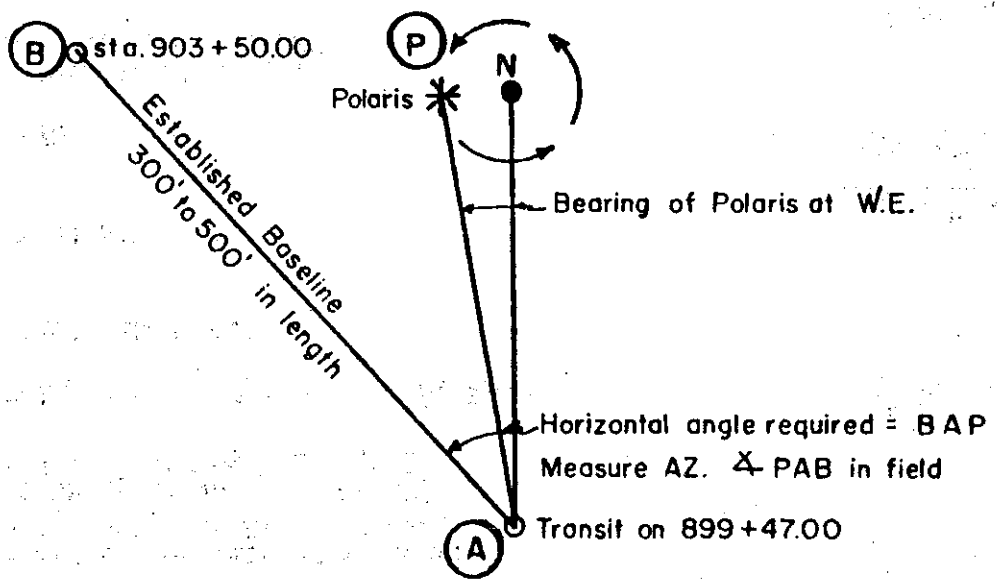


235.9 Example No. 2 POLARIS AT WESTERN ELONGATION (W.E.)



POSITION OF CONSTELLATIONS WHEN POLARIS IS AT WESTERN ELONGATION

(Approximate location)



GRAPHIC FIELD POSITION WHEN POLARIS IS AT WESTERN ELONGATION

(Approximate location)

EXAMPLE NO. 2 POLARIS AT WESTERN ELONGATION (W.E.)

Meridian by observation on Polaris at Concord Airport on December 9, 1970
Solar Ephemeris Tables for 1970 - Booklet by W. & L. E. Gurley
Latitude: 43°12'30" Longitude: 71°31'30"

Convert Latitude to decimals of a degree: 43°12'30" = 43.208°

Convert Longitude to hours, minutes, and seconds and to decimals of an hour:
75th Meridian to Concord Airport = 75°00'00" - 71°31'30" = 3°28'30" of Arc.
3°28'30" Arc = $0^h\ 13^m\ 54^s$ in Time. Time at the 75th Meridian = $5^h\ 00^m\ 00^s$.
Time at Concord Airport = $5^h\ 00^m\ 00^s - 0^h\ 13^m\ 54^s = 4^h\ 46^m\ 06^s = 4.768^h$

Civil Time, U. C. @ Greenwich, Eng. (Table for Polaris at U. C.) on Dec. 6, 1970	=	$21^h\ 03^m\ 53.0^s$
Reduction to date for Dec. 9, 1970 (Table for Polaris at U. C.) Variation per day for Dec. 6 = $-3^m\ 56.7^s$ Variation per day for Dec. 16 = $-3^m\ 56.9^s$ Interpolation for Dec. 9 = $0.3 \times 0.2^s = 0.06^s$ = Negligible Use $-3^m\ 56.7^s$ per day x 3 days = $-0^h\ 11^m\ 50.1^s$	=	$-0^h\ 11^m\ 50.1^s$
Civil Time, U. C. @ Greenwich, Eng. on Dec. 9, 1970	=	$20^h\ 52^m\ 02.9^s$
Reduction to Place (Concord Airport) (Table for Polaris at U. C.) Variation per hour: Use -9.86^s, Hour at Concord Airport = 4.768^h Reduction = $4.768^h \times 9.86^s = -0^h\ 00^m\ 47.0^s$	=	$-0^h\ 00^m\ 47.0^s$
Civil Time, U. C. @ Concord Airport on Dec. 9, 1970	=	$20^h\ 51^m\ 15.9^s$

EXAMPLE NO. 2 (Continued) POLARIS AT WESTERN ELONGATION (W.E.)

Civil Time, U. C. @ Concord Airport on Dec. 9, 1970 = $20^h\ 51^m\ 15.9^s$

Time interval for W.E. for Lat. 43°12'30" (Table for Polaris at Elongation)
Time interval for Lat. = 42°00'00" = $+5^h\ 55.9^m$ = $+5^h\ 55^m\ 54^s$
Time interval for Lat. = 44°00'00" = $+5^h\ 55.7^m$ = $+5^h\ 55^m\ 42^s$
Difference = $0^h\ 00^m\ 12^s$
Interpolation for Lat. = 42°12'30" = $0.208°/2 \times 12^s = 1.25^s$, Use 1.2^s
Time interval for Lat. = 42°12'30" = $+5^h\ 55^m\ 54^s$ (-) $+0^h\ 00^m\ 01.2^s$ = $+5^h\ 55^m\ 52.8^s$ = $+5^h\ 55^m\ 52.8^s$

Civil Time, W.E. @ Concord Airport on Dec. 9, 1970 = $26^h\ 43^m\ 08.7^s$

Adjustment for Day = -24^h = $-24^h\ 00^m\ 00^s$

Civil Time, W.E. @ Concord Airport on Dec. 10, 1970 = $2^h\ 43^m\ 08.7^s$

Reduction to Eastern Standard Time @ 75th Meridian
75th Meridian = $5^h\ 00^m\ 00^s$, Concord Airport = $4^h\ 46^m\ 06^s$
Difference = $5^h - 4^h\ 46^m 06^s = 0^h\ 13^m\ 54^s$ = Reduction = $-0^h\ 13^m\ 54.0^s$

Civil Time, W.E. @ Concord Airport on Dec. 10, 1970 = $2^h\ 29^m\ 14.7^s$ a.m.

Convert Date and Time into decimals of a day.
Dec. 10 = 10.0000^d, $2^h\ 29^m\ 14.7^s = 2.4874^h$
$2.4874^h / 24^h = 0.1036^d$ ∴ Dec. 10 @ $2^h\ 29^m\ 14.7^s = 10.1036^d$

Civil Time, W.E. @ Concord Airport on Dec. 10, 1970 = 10.1036^d

EXAMPLE NO. 2 (Continued) POLARIS AT WESTERN ELONGATION (W.E.)

Civil Time, W.E. @ Concord Airport on Dec. 10, 1970	=	10.1036^d
Reduction to Greenwich, Eng. Civil Time (G.C.T.), Difference in Longitude Difference in Longitude = $4^h\ 46^m\ 06^s = 4.768^h$ Convert to decimals of a day $\therefore\ 4.768^h / 24^h = 0.1987^d$ Reduction to G.C.T., Difference in Longitude	=	$+0.1987^d$
G.C.T. of W.E. at Concord Airport	=	10.3023^d
G.C.T. of Tabular Declination (Table for Polaris at U. C.) G.C.T. of Tabular Declination from Table for Dec. 6, 1970 = $21^h\ 03^m\ 53^s$ Convert this Date and Time to decimals of a day. Dec. 6 = 6.0000^d and $21^h\ 03^m\ 53^s = 21.0647^h / 24^h = 0.8777^d$ $\therefore$ Dec. 6 @ $21^h\ 03^m\ 53^s = 6.8777^d$	=	-6.8777^d
Elapsed Time between W.E. and "Table for Polaris at U. C."	=	3.4246^d
Declination, Polaris (Table for Polaris at U. C.) Apparent Declination for Dec. 6, 1970 = +89°07'00" (+) +71"	=	89°08'11"
Reduction to Civil Time, W.E. @ Concord Airport on Dec. 10, 1970 (Table for Polaris at U. C.) Apparent Declination for Dec. 6 = 89°07'71" Apparent Declination for Dec. 16 = 89°07'74" Difference = 03" in 10 days $\therefore$ $03"/10^d$ = 00.3" per day Reduction = 3.4246^d x 00.3" = 01.03", use 01.0"	=	-0°00'01"
Declination, Polaris, W.E.	=	89°08'10"

EXAMPLE NO. 2 (Continued) POLARIS AT WESTERN ELONGATION (W.E.)

Declination, Polaris, W.E. = 89°08'10"

Obtain Azimuth of Polaris West of North. (Angle in N.W. Quadrant)
(Table for Azimuth at Elongation)
From this table, interpolate between Latitudes for declination and then, if necessary, interpolate between declinations for the Azimuth.
Declination = 89°08'10", Latitude = 43°12'30" = 43.208°
Lat. 43°00'00", declination = 89°08'10", Angle = 1°10'52"
Lat. 44°00'00", declination = 89°08'10", Angle = 1°12'04"
Azimuth difference = 0°01'12", Lat. difference = 0.208°
$\therefore$ 72" x 0.208° = 14.976", use 15", Angle = 1°10'52" + 15" = 1°11'07"

Bearing of Polaris = 1°11'07" N.W.

Polaris at Western Elongation @ the Concord Airport is on Dec. 10, 1970, at $2^h\ 29^m\ 14.7^s$ a.m. and has a Bearing of Polaris of 1°11'07" N.W.

Black C.P
White ⊼
Green Ch.
Brown ⊥

12-10-70

POLARIS OBSERVATIONS

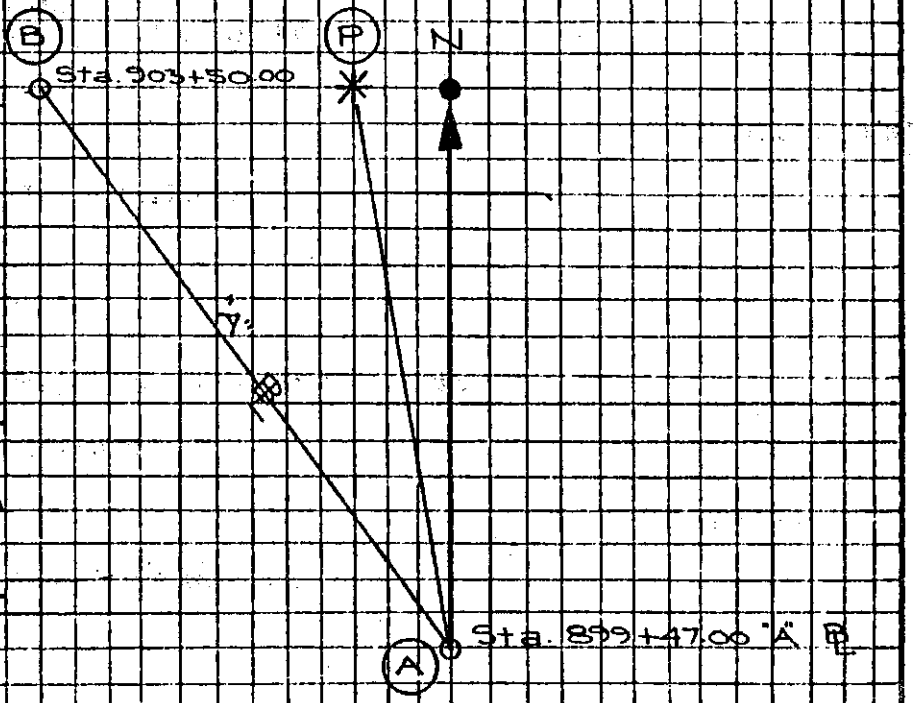
Cold & Clear

3

Polaris at Western Elongation		
Civil time U.C. @ Greenwich on Dec. 6, 1970		
* Eph. table for polaris at U.C. =	$21^h\ 03^m$	53.0^s
Reduction to date for Dec. 9, 1970 Eph. table for Polaris at U.C. =	$-0^h\ 11^m$	50.1^s
Civil time, U.C. @ Greenwich on Dec. 9, 1970 =	$20^h\ 52^m$	02.9^s
Reduction to place (Concord Airport) Eph. table for Polaris at U.C. =	$-0^h\ 00^m$	47.0^s
Civil time U.C. @ Concord Airport on Dec. 9, 1970 =	$20^h\ 51^m$	15.9^s
Time interval for W.E. for lat. 43°12'30" Eph. table for Polaris at elongations =	$+5^h\ 55^m$	52.8^s
Civil time W.E. @ Concord Airport on Dec. 9, 1970 =	$26^h\ 43^m$	08.7^s
Adjustment for day =	$-24^h\ 00^m$	00.0^s
Civil time W.E. @ Concord Airport on Dec. 10, 1970 =	$2^h\ 43^m$	08.7^s
Reduction to East. Std. time @ 75th Meridian =	$-0^h\ 13^m$	54.0^s
Civil time W.E. @ Concord Airport on Dec. 10, 1970 =	$2^h\ 29^m$	14.7^s AM
Conversion to day =	10.1036 d	
Reduction G.C.T., Diff. in long. =	+ 0.1987 d	
G.C.T. of W.E. @ Concord Airport =	10.3023 d	
G.C.T. of tabular declination (Eph. Tab.) for Polaris at U.C. Dec. 6 1970 =	-6.8777 d	
Elapsed time between W.E. and Eph. table for polaris at U.C. =	3.4246 d	

* Ephemeris tables for 1970 by W.E.M.E. Gurley

Location of Point (A)
Concord Airport
Lat. 43° 12' 30" Scaled
long. 71° 31' 30" Scaled



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Black C.r.
White π
Green Ch.
Brown ⊥

12-10-70

3

POLARIS OBSERVATIONS

Cold

Polaris at Western Elongation

Computations continued from previous page

Declination, Polaris (Eph table for Polaris at U.C.)
Apparent decl. for Dec. 6, 1970 = 89°-08'-11"
Reduction to civil time W.E. at Concord Airport on Dec. 6, 1970 (Eph tab/c for Polaris at U.C.) = -0°-00'-01"

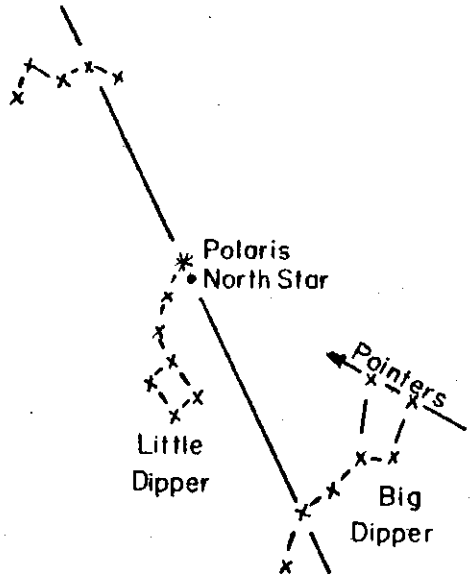
Declination, Polaris, W.E. = 89°-08'-10"

Eph. table for azimuth at elongation
Angle of Polaris west of North = 1°-11'-07"
Bearing of Polaris at W.E. = N 1°-11'-07" W
Time of Polaris at W.E. = 2^h 29^m 14.7^s AM
East Std. time

Watch set from radio for East Std. time.
Time allowed for observation = 10 minutes
π on Pt. A, Site on Pt. P (North star) ⅔ rt. to Pt. B See sketch on previous page.

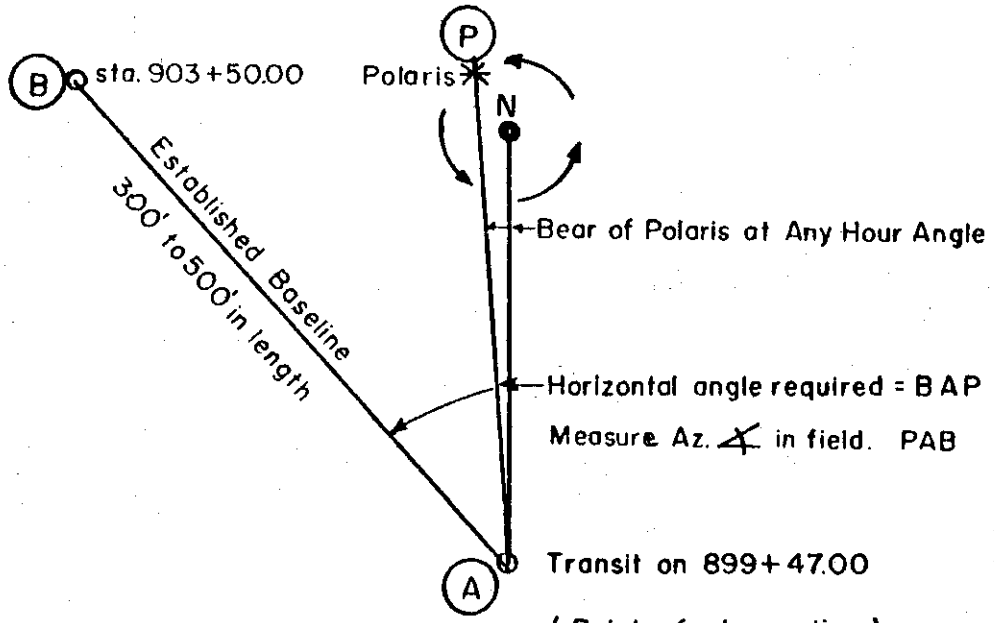
H	M	S	°	'	"
2	29	00	335	38	37
2	30	00	311	17	14
2	31	00	286	55	51
2	32	00	262	34	28
262°-34'-28" + 1080° ÷ 4 =			335°	38'	37"
∠ PAB = 335° -			38'-37"		
∠ BAP = 360° -			335°-38'-37" =	24°	21' 23"
24°-21'-23" + 1°-11'-07" =			25°	32'	30"
Bearing AB = N 25° 32' 30" W					

235.10 Example No. 3 POLARIS AT ANY HOUR ANGLE



POSITION OF CONSTELLATIONS WHEN POLARIS IS AT ANY HOUR ANGLE

(Approximate locations)



GRAPHIC FIELD POSITION WHEN POLARIS IS AT ANY HOUR ANGLE

(Approximate locations)

EXAMPLE NO. 3 — POLARIS AT ANY HOUR ANGLE

Meridian by Observation on Polaris at Concord Airport on Dec. 9, 1970
at $9^h\ 24^m\ 30^s$ Eastern Standard Time
Solar Ephemeris Tables for 1970 - Booklet by W. & L.E. Gurley
Latitude: 43°12'30" Longitude: 71°31'30"

Eastern Standard Time (E.S.T.) is taken at the 75th Meridian and is 5^h from Greenwich, Eng.

E.S.T. of Observation @ Concord Airport on Dec. 9, 1970	=	Dec. $9^d\ 9^h\ 24^m\ 30.0^s$ p.m
Plus 12^h since time of Observation is p.m.	=	$+12^h$
Civil Time, E.S.T. of Observation @ Concord Airport	=	$9^d\ 21^h\ 24^m\ 30.0^s$
Reduction to Greenwich Civil Time (75th Meridian to Greenwich)	=	$+\ 5^h$
Greenwich Civil Time (G.C.T.) of Observation	=	$9^d\ 26^h\ 24^m\ 30.0^s$
Adjustment for day since hours exceed 24	=	-24^h
G.C.T. of Observation	=	Dec.$10^d\ 2^h\ 24^m\ 30.0^s$
Greenwich Hour Angle (G.H.A.) (Table-Polaris for 0^h G.C.T.)	=	47°06.9'
Convert minutes to seconds		
G.H.A., Polaris for 0^h G.C.T.,	=	47°06'54.0"
Correction for Time, Time = $2^h\ 24^m\ 30.0^s$, (Table for Corrections for G.H.A.)		
Correction for 2^h = 30°04.9'		
Correction for 24^m = 6°01.0'		
Correction for 30^s = 0°07.5'		
Correction Total = 36°13.4' = 36°13'24"		
G.H.A., Polaris for 0^h G.C.T.	=	47°06'54.0"
Correction for Time	=	+36°13'24.0"
G.H.A., Polaris at Time of Observation	=	83°20'18.0"
Longitude @ Concord Airport, (Minus since it is westerly)	=	-71°31'30.0"
Local Hour Angle (L.H.A.), Polaris at Time of Observation = t	=	11°48'48.0"

EXAMPLE NO. 3 (Continued) POLARIS AT ANY HOUR ANGLE

G.C.T. of Observation	=	Dec. $10^d\ 2^h\ 24^m\ 30.0^s$
Convert time to decimals of a day		
$2^h\ 24^m\ 30^s = 2.4083^h / 24^h = 0.1004^d$		
G.C.T. of Observation	=	10.1004^d
G.C.T. of Tabular Declination for Dec. 6 (Table for Polaris at U. C.)	=	$21^h\ 03^m\ 53.0^s$
Convert G.C.T. to decimals of a day		
$21^h\ 03^m\ 53^s = 21.0647^h / 24^h = 0.8777^d$		
G.C.T. of Tabular Declination for Dec. 6	=	6.8777^d
G.C.T. of Observation	=	10.1004^d
G.C.T. of Tabular Declination	=	$-\ 6.8777^d$
Elapsed time between Observation and Tabular Declination (Difference)	=	3.2227^d
Declination, Polaris, U. C., G.C.T. for Dec. 6 (Table for Polaris at U. C.)	=	89°07'71.0"
Reduction to time of Observation = 3.2227^d x 3/10" = 0.97"	=	+ 0°00'01.0"
Declination, Polaris at time of Observation	=	89°08'12.0"

L.H.A. = t, Polar Distance = p, Altitude = h, Bearing of Polaris = Z

Polar Distance = 90° - Declination = 90°89°08'12" = 0°51'48" = 0°51.800'

Find Altitude, Lat. = Alt. - Polar Dist. x Cos hour Angle
43°12'30" = Alt. -0°51.800' x Cos 11°48'48", Alt. = 44°03'12"

$$Z = \frac{\text{Sin } t \times p}{\text{Cos } h} = \frac{\text{Sin } 11°48'48"}{\text{Cos } 44°03'12"} \times 0°51.800' = 0°14'46"$$

Bearing of Polaris = N 0°14'46" W, since L.H.A. is less than 180°, the body is west of north.

Black C.P.
White ⊼
Green Ch.
Brown L

12 -70

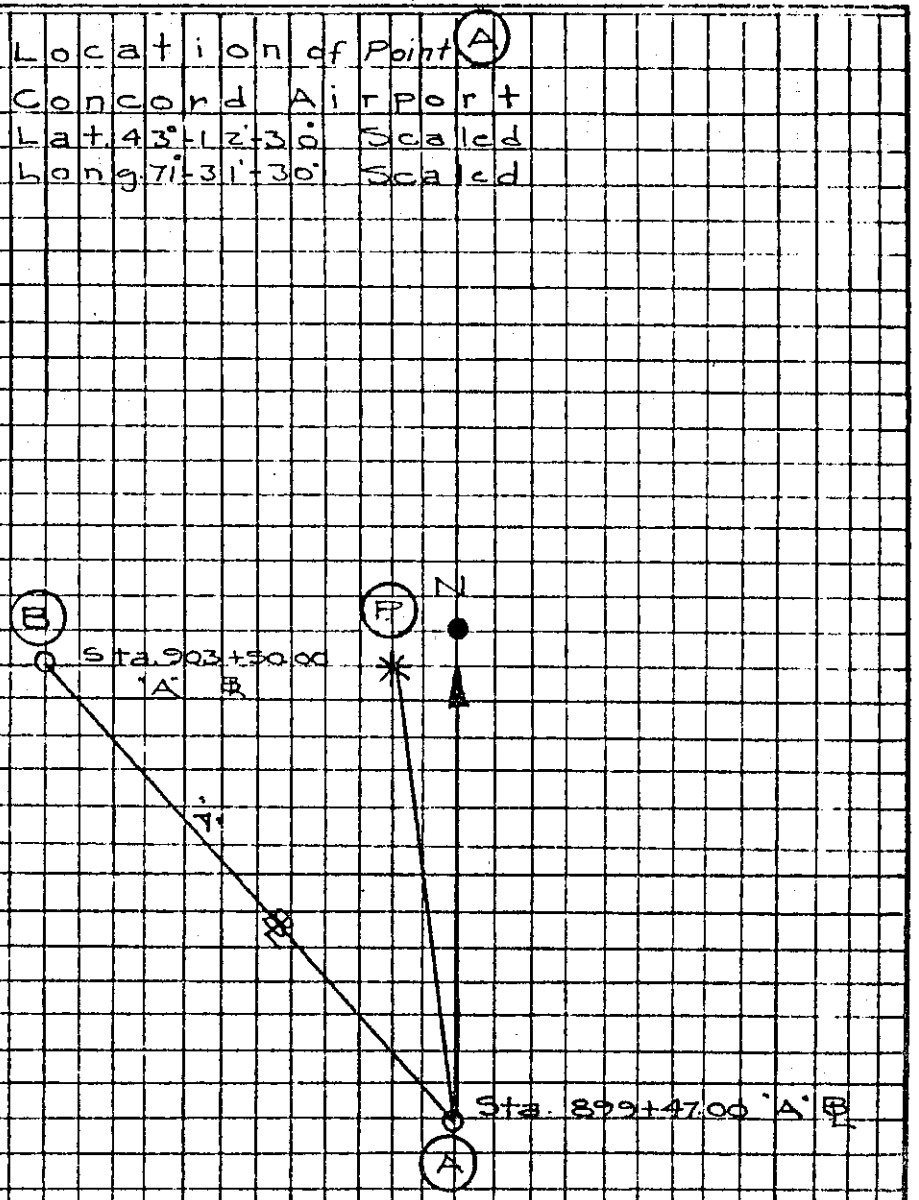
POLARIS OBSERVATIONS

Cold & Clear 3

Polaris at any Hour Angle

Time of observation	= 9h 24m 30s P.M. East Std. Time
E.S.T. of obs. @ Concord Airport on Dec. 9, 1970	= 9d 9h 24m 30.0s
Adjust for P.M.	= + 12h 00m 00.0s
Civil time, E.S.T. of obs. @ Concord	= 9d 21h 24m 30.0s
Reduction to Greenwich Civil time	= + 5h 00m 00.0s
Greenwich Civil Time of obs.	= 9d 26h 24m 30.0s
Adjust for day	= - 24h 00m 00.0s
Greenwich civil time of obs. = Dec.	10d 2h 24m 30.0s
Greenwich hour angle	
* Eph. Table Polaris For 0h G.C.T.	= 47°-06'9"
"	= 47°-06'-54.0"
Correction for time (2h 24m 30.0s) Eph. Table corrections for G.H.A.	= +36'-13'-24.0"
G.H.A. Polaris at time of obs.	= 83°-20'-18.0"
Longitude @ Concord Airport	= - 71°-31'-30.0"
L.H.A. Polaris at time of obs. = t	= 11°-48'-48.0"
G.C.T. of obs. = 10d 2h 24m 30.0s	= 10.1004d
G.C.T. of Tabular Declination for Dec 6	- 6.8777d
Elapsed time between obs & Tab. Decl.	= 3.2227d
Declination, Polaris, U.C. G.C.T. for Dec. 6	
Eph. Table for Polaris at U.C.	= 89°-08'-11.0"
Reduction to time of obs.	= + 0°-00'-01.0"
Declination, Polaris at time of obs.	= 89°-08'-12.0"

* Ephemeris Tables for 1970 by W. El. E. Gurley



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Black C.P.
White ⊼
Green Ch.
Brown 1

12-9-70

POLARIS OBSERVATIONS

Cold & Clear 3

Polaris at any Hour Angle

Computations Cont'd from previous page.

L.H.A. = t, Polar distance = P
Altitude = h, Bearing of Polaris = Z

Polar Dist. = 90° - Decl. = 90°-89°-08'-12" = 0°51'-48"

Latitude = Altitude - Polar dist. x Cos hour angle
43°-12'-30" = h - 0° 51'800" x Cos 11°-48'-48"
h = 44°-03'-12"

Bearing of Polaris = $Z = \frac{\sin t}{\cos h} \times P$

$Z = \frac{\sin 11°-48'-48"}{\cos 44°-03'-12"} \times 0°\cdot 51'\cdot 800" =$ 0°-14'-46"

Bearing of Polaris = N 0°-14'-46" W.

Watch set from radio for East. std. time and time of observation made at 9h 24m 30s P.M.
⊼ on point A, sits on point P (North Star) ⊼s rt to point B
Time allowed for observation = 4 minutes

H	M	S	°	'	"
			334	42	16
			309	24	32
			284	06	48
			258	49	04

258°-49'-04" + 1080° ÷ 4 = 334° 42' 16"
∠PAB = 334°-42'-16"
∠BAP = 360° - 334° 42 16 = 25°-17'-44"
25°-17-44 + 0°-14'-46" = 25°-32'-30"
Bearing AB = N 25°-32'-30" W

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SUN OBSERVATIONS

The most convenient method of obtaining the true bearing of a line is by measuring an altitude of the sun and computing the sun's azimuth by spherical trigonometry. This observation may be made in a few minutes time while the survey is in progress and is therefore preferred by many surveyors, rather than by taking observations on Polaris. Polaris observations consume more time and usually require a special trip to the point of observation. By observing the sun, a bearing of a line may be determined within 2± minutes; however, by averaging several observations, a higher accuracy may be obtained. Before attempting to calculate the azimuth of the sun, examine the intervals between the successive watch times, vertical angles, and horizontal angles. These should be very nearly proportional and if there is any sudden change in relation between these intervals, a mistake becomes evident and should be investigated. In New Hampshire, sun observations should be taken between the hours of 9:00 a.m. and 11:00 a.m. or between the hours of 2:00 p.m. and 4:00 p.m., when the vertical angle of the sun with the horizon is not less than 20° and not greater than 40°. Therefore, sun observations should not be attempted between the dates of November 1 and February 10. Vertical angles less than 20° have an uncertain parallax correction and vertical angles over 40° cause difficulty in the use of a reflector card. Sun observations during the middle hours of the day should also be avoided because the change in vertical angle of the sun is too small as compared

with the change in horizontal angle of the sun.

The surveyor should never attempt to view the sun directly through the telescope of a transit, and it should be also noted that ordinary sunglasses will not provide adequate protection against the brightness of the sun. Most instrument companies make a special colored viewing glass, however a piece of any smoked glass will suffice. With this colored glass held in back of the eye piece, the surveyor may then view the sun directly through the telescope. All three horizontal transit hairs cannot be seen at once through the colored glass, so care should be taken not to use a stadia hair by mistake. If a colored glass is not available, the surveyor may observe the sun indirectly with a white reflector card or sheet of paper. This reflector card is held about six inches behind the eyepiece and at right angles to the telescope. Do not hold the reflector card too close to the eyepiece of the transit, as the brightness of the sun's image will obscure the cross hairs. When the telescope is moved into position, the sun's image will flash across the reflector card and by focusing the eyepiece, a sharp shadow of the cross hairs will also be produced on the card. For the exact procedures with a colored glass or reflector card, see Ephemeris tables.

There are two methods of making sun observations - (1) by setting one point of tangency with the transit centered on the sun. This is known as "Center-Tangent Method," and (2) by setting two points of tangency with the transit centered on the edge of the sun. (See diagrams on Page No. 70 .) This is known as the "Quadrant-Tangent Method," and is the only method discussed in this manual. Both of these methods are

described in detail in most Ephemeris tables and elementary surveying text books.

The first step in taking sun observations is to establish a convenient base line from 300 to 500 feet in length and having good vertical clearance. The transit may be placed at either end of the base line and back sights or fore sights may be used as the initial sight; however in all cases the horizontal angles must be taken clockwise and always read the "A" scale. Always sight on the base line first before observing the position of the sun. In general, all preparatory field work necessary to taking sun observations should be arranged beforehand, so that the measuring and recording of angles and time may be done as quickly as possible. A total of six readings should not take over 15 minutes. In making sun observations, it is necessary to take three observations with the telescope direct and three with the telescope inverted and taken in diagonal quadrants as shown on diagrams on Page No. 70 . When observations are made in the a.m., use quadrants 2 and 4, and in the p.m., use quadrants 1 and 3. Always be sure that the sun is in the proper quadrant. The sun moves rapidly in both altitude and azimuth with the apparent motions being from west to east and vertically upward in the a.m. and vertically downward in the p.m. Because of these two simultaneous motions of the sun, there is a certain amount of difficulty in setting two points of tangency with the transit; therefore it is necessary for one member of the survey party to hold the colored glass or white reflector card, while another operates the transit.

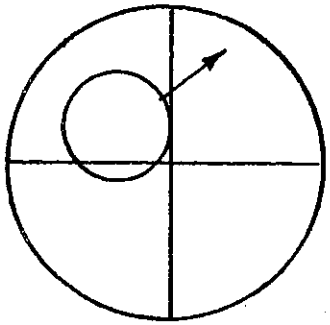
The transitman, after taking a sight on the base line, follows the sun's movements both horizontally and vertically until both hairs are tangent to the sun. When both hairs are tangent, the transitman calls "mark" and the time is read. Then the horizontal and vertical angles are read and all items are recorded. This procedure is repeated until all the observations are made.

It is necessary for the surveyor to have a U.S.G.S. Quadrangle Map of the area involved, to enable him to scale the Latitude and Longitude of the point of observation. The Eastern Standard Time should be known within the nearest 10 minutes, the approximate elevation of the point of observation should also be known and can be interpolated from a U.S.G.S. Quadrangle Map, and the temperature should be recorded. Before taking sun observations, the surveyor should acquaint himself with the time relationships, Ephemeris tables, and the example given in this manual. For time relationships, see Polaris, Page 43 through Page 44 of this manual. Gurley Ephemeris tables are recommended and were used entirely for the example shown in this manual. Ephemeris tables of makes other than Gurley are often similar, but not identical. In the case of sun observations, there are three corrections to be applied to the observed vertical angle and they can always be found in Ephemeris tables. The first correction is for Parallax. It will never exceed 9 seconds and is always added. The second correction is for Refraction. This correction is also quite small (minutes and seconds), is adjusted for temperature and elevation, and is always subtracted. The third correction is for

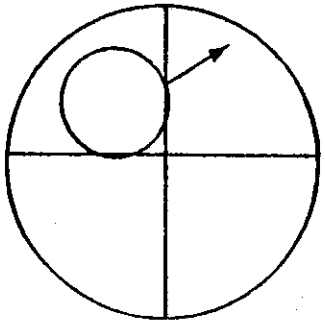
semi-diameter. This correction is not applied in the "Quadrant-Method" when opposite quadrants are observed. Basically, the surveyor, after taking sun observations, will have to compute the adjusted sun's altitude and the sun's declination as part of the field notes; then from these notes this information is put onto a computer input data sheet. See Page 73 of this manual. The results, sun's azimuth, will be shown on the computer output sheet. See Page 74 of this manual. The true bearing of the survey base line can then be established by applying the horizontal angle to the sun's azimuth.

236.1 DIAGRAMS OF THE SUN AS VIEWED DIRECTLY THROUGH A TELESCOPE

QUADRANT-TANGENT OBSERVATIONS IN THE A.M.



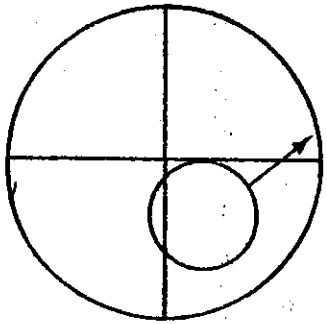
Sun before observation



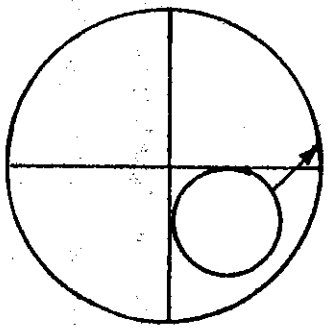
Sun at observation

Telescope direct in second quadrant

(Repeat three times)



Sun before observation

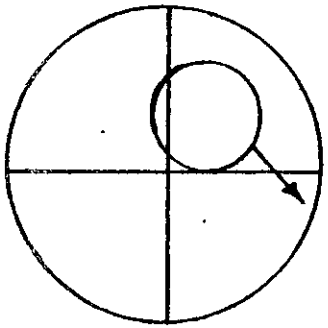


Sun at observation

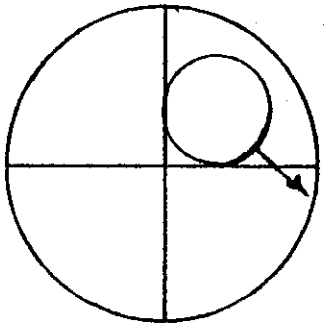
Telescope inverted in fourth quadrant

(Repeat three times)

QUADRANT-TANGENT OBSERVATIONS IN THE P.M.



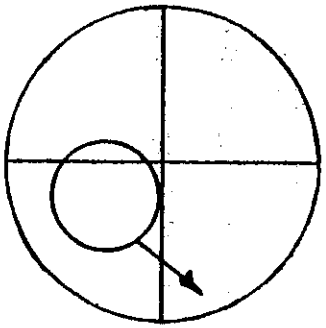
Sun before observation



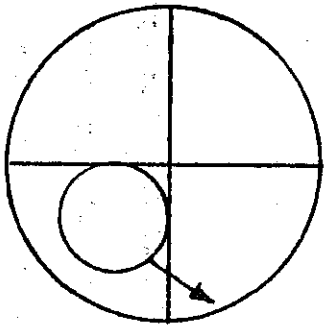
Sun at observation

Telescope direct-first quadrant

(Repeat three times)



Sun before observation



Sun at observation

Telescope inverted in third quadrant.

(Repeat three times)

NOTE: Arrows show general path of the sun.

EXAMPLE NO. 1 (Sun Observations)

Meridian by Observation on the sun at Concord Airport on July 29, 1970
Solar Ephemeris Tables for 1970 - Booklet by W. & L.E. Gurley
Latitude: 43°12'30" Longitude: 71°31'30"
From Field Notes - Assume Average Vertical Angle = 37°59'40" (Apparent Altitude),
Average Eastern Standard Time = $9^h\ 12^m\ 10^s$, Temperature = 75°F, and approx. Elev. = 245'.
The "Quadrant-Method" of Observation was used with opposite Quadrants.
Eastern Standard Time (E.S.T.) is taken at the 75th Meridian and is 5^h from Greenwich, Eng.

E.S.T. of Observation @ Concord Airport on July 29, 1970	=	$9^h\ 12^m\ 10^s$ a.m.
Plus 5^h to obtain the declination of the sun for 0^h Greenwich Civil Time	=	$+\ 5^h$
Greenwich Civil Time	=	$14^h\ 12^m\ 10^s$
Tabular declination for July 29, 1970, 0^h G.C.T. (Table - 0^h G.C.T.)	=	18°54'27"
Reduction to Time of Observation = G.C.T.^{h} times difference per hour		
Reduction to Time of Observation = $14^h\ 12^m\ 10^s$ x 35.39" = 14.2028^h x 35.39"	=	+ 8'23"
Apparent declination of the sun at time of Observation	=	19°02'50"
Average Vertical Angle (Apparent Altitude of Sun)	=	37°59'40"
Add Parallax Correction (Table - Parallax of Sun in Altitude)		
Add Parallax Correction = Interpolation for 37°59'40"	=	+ 07"
Subtract Refraction Correction (Table - Mean Refraction in Altitude)		
Subtract Refraction Correction = 1'14" x Coef. for Barometer x Coef. for Temp.		
Subtract Refraction Correction = 1.1233' x 1.0 x 0.95	=	- 01'10"
Corrected Sun's Altitude = h	=	37°58'37"

There is no correction for semi-diameter, since the "Quadrant-Method" with opposite Quadrants was used in this example.

236.3 FIELD NOTES

CONCORD AIRPORT P-6789

SUN OBSERVATIONS

Black C.P.
White ⊼
Green Ch.
Brown ⊥

7-29-70

Temp.=75°3
Clear

Temperature = 75° F. Approx. elev. = 245'
Watch set from radio for East Std. time
⊼ on pt. A, site on point B ⊼'s rt. to Sun
White reflector card used for observations

Shot no.	Tel.	Quad.	Time	Horiz ∠	Vert. ∠
1	D	No. 2	9-06-00	50°-00'-30"	36°-40'
2	D		9-08-30	100°-01'-30"	37°-05'
3	D		9-10-30	150°-02'-45"	37°-26'
4	I	No. 4	9-14-00	50°-01'-00"	38°-34'
5	I		9-16-00	100°-02'-00"	38°-56'
6	I		9-18-00	150°-03'-00"	39°-17'
Averages =			9-12-10	50°-00'-49"	37°-59'-40"

Watch set from radio for East Std. time

E.S.T. of obs. @ Concord Airport on July 29, 1970 = 9h 12m 10s AM

+5h

Greenwich Civil time = 14h 12m 10s

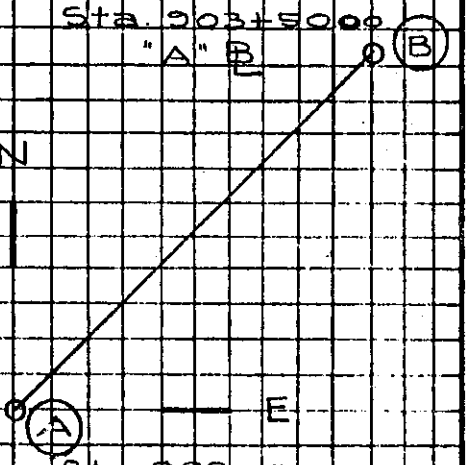
* Tabular decl. for July 29, 1970 0h G.C.T. = 18°-54'-27"
* Reduction for time of obs. = +0°-08'-23"

Apparent decl. at time of obs. = 19°-02'-50"

Vertical angle = 37°-59'-40"
* Parallax Correction = + 0°-0'-07"
* Refraction Correction = - 0°-01'-10"
Semi-diam. Correction not req'd.
Sun's altitude = 37°-58'-37"

* Ephemeris tables for 1970 by W.E.L.E. Gurley

Location of Point (A)
Concord Airport
Lat. 43° 12' 30" Scaled
Long. 71° 31' 30" Scaled



236.4 INPUT DATA

* Project: Concord Airport P-6789

* Sun Observations

* John M. Jewett , July 29,1972

ALTITUDE																						DECLINATION																						LATITUDE																					
°							'								"							°							'							"							°							'							"						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
		3	7	·					5	8	·					3	7	·	0				1	9	·					0	2	·					5	0	·	0				4	3	·					1	2	·					3	0	·	0	

OUTPUT DATA

FORTRAN IV PROGRAM SUNSHT (LINK-EDITED AS SUNSHT) STARTED --- 03/03/72

*PROJECT: CONCORD AIRPORT PROJECT NO. P-6789

*SUN OBSERVATIONS

*JOHN M. JEWETT, JULY 29, 1970

	DEGREES	MINUTES	SECONDS
INPUT			
ALTITUDE	37.	58.	37.00
DECLINATION	19.	2.	50.00
LATITUDE	43.	12.	30.00
OUTPUT			
SUN'S AZIMUTH	99.	30.	45.15
SUN'S HOUR ANGLE	55.	19.	50.26

**FORTRAN ** STOP 99999

CONSTRUCTION SURVEYS

SECTION III

INDEX

300 CONSTRUCTION PLANS FOR LAYOUT WORK

The Party Chief should thoroughly study the construction plans that are delivered to him during the bid advertising stage. He will have a set of 50 scale working plans which have been reduced photographically to approximately half scale, a set of 50 scale right of way prints (where right of way is to be purchased) and a set of 50 scale bridge plans, where needed.

301 CONSTRUCTION SURVEY REQUEST PROCEDURES

All construction requests for services of a survey party will be made by the Project Engineer directly to the Office of the Location Engineer. The survey party will then accomplish only that which was specifically stated in the request, without deviations.

302 CARE AND USE OF FIELD NOTEBOOKS

When contract projects are advertised for construction, the Highway Design Division will issue to the Location Section all books that were used on the preliminary survey. The Survey Supervisor will in turn issue these books to the Party Chief assigned to the construction layout. Additional new or partially filled books will be assigned as needed. As soon as the State field office is set up, the Party Chief will store these books each night in the office safe, in a drawer assigned by the Project Engineer. It is important to leave the books at the field office, readily available to the Project Engineer or to other survey crews that may be assigned to the project. Any transfer of books to the

Concord Office during the construction phase must be made through the Survey Supervisor. When a project is closed down for the winter, the field books should be returned to the Location Section. This rule will also apply at the termination of a project, before the contractor moves out of the field office.

All rules pertaining to indexing, referencing and legibility found under PRELIMINARY SURVEY will apply to the construction phase. Other special rules pertaining to the use of notebooks will be given under the various items of CONSTRUCTION SURVEY.

303 INITIAL LAYOUT

The Initial Layout stage includes all survey items which will be initiated after the project has been advertised and which will hopefully be completed before the bids are opened. The items are listed in the suggested order of completion.

303.1 REHABILITATION OF SURVEY LINES AND CONSTRUCTION LINE CHANGES

Any construction line change shown on the plans must be established in the field as soon as possible, field-closing the layout to be certain that no mistakes have been made.

Existing construction lines must be replaced as needed. This will normally be done in stages, as the layout work progresses.

Occasionally a survey crew may be given a construction line change to stake prior to advertising for bids, in which case charges will be to the preliminary phase of the project.

303.2 LINE TIES

In urban areas it is sometimes necessary or more practical to use swing ties. Three objects should be located outside of the work area, where tie points can be conveniently established for the control station. The angle from the control point to any pair of swing ties should be approximately 60 to 90 degrees. Common swing tie locations are corners of foundations or other similar objects. Care should be taken that the points picked are at a level which can be used during all stages of construction. When using corners of foundations or corner boards of buildings, it is also important to indicate the point from which the measurement was taken -- such as the height above the ground or the number of concrete blocks above the ground.

In urban areas it is a must that the Chief ask for permission from the property owners before putting stakes of any kind outside of the State right of way. Putting tie nails in buildings or in trees or people's lawns is not allowable.

Any stakes that are placed on lawns must be driven flush.

Existing line ties should be checked, and replaced or added to as needed.

Where there are construction line changes it will be necessary to tie out both the construction line and the survey line, since final cross sections will be taken from the survey line.

Swing ties to trees will not be used in urban areas but may be used in rural areas on betterment type surveys or as very temporary line ties on other projects. The nails on trees should be located in such a

manner that it will be possible to reproduce the distance from the tree without bending the tape. The tie notes should show the size and location of the tie nails.

Tie points should be established a maximum distance of 500 feet apart along the center line. The plan profile of finished grade should be studied for the location of vertical curves, in order to insure level sight distance between tied out controls. Sharp curves may require additional ties, where trees or other obstacles may present a problem in turning off deflections with the transit. Be sure that the nearest tie to the center line is located a minimum of 30' outside the slope lines. Hub ties are preferable, using standard survey stakes or oak hubs driven flush with the ground, with nails driven through yellow plastic ribbon marking line and distance on each hub. Three hub ties should be used on one side of the center line. Where practical, there should be a minimum of 50' and preferably 100' or more between each hub. It will also be helpful to place one of the hubs on the right of way line. A reference stake, slanted toward the hub, will be driven about 3" into the ground beside each tie point. The reference stake will be marked with dri-mark showing the station and offset distance from center line. A tall riser flagged with yellow plastic ribbon will be driven on the opposite side of each tie point.

Hub ties are preferably set at 90 degrees to the center line, and so shown in the alignment book on the sketch pages with the alignment. Occasionally it may be necessary to tie out a point on a skew angle, to

avoid some object such as a large tree. Be sure to show the skew angle on your alignment sketch. To avoid possible errors during construction, the exposed surface of the reference stake should be marked "Skew Tie." See Plate No. 32.

303.3 STAKING FOR RIGHT OF WAY BOUNDS

The survey crew will be expected to set all bound points during the initial construction layout stage, unless the bounds fall within the work area. A complete list of bound point locations should be recorded in the alignment book at the time of the original stakeout (for the Project Engineer's use) and as bound points are set during the construction stages, each location should be check-marked, dated and initialed in the book. See Plate No. 38.

Immediately upon completion of the initial layout, the Chief of Party will forward to the Location Engineer a list showing the station and offset of all bound points that could not be set at that time. Note the reason why each point could not be set. The Location Engineer will then send this information in a letter to the Construction Division. Bound points that cannot be set at this time will be set at a later date when the center line is being run for another purpose. Center line is not to be run for the one purpose of setting bound points. A record should be kept by the Chief of Party of any bound points that have to be reset because the Contractor has carelessly knocked out the original bound ties. This record should be forwarded to the Location Engineer after the bound points have all been set.

The accepted method of setting bound points is to set a hub stake at the bound location with straddle stakes. A reference stake at the bound location should show the station and offset. The straddle stakes should be set by transit about 4 to 5 feet either side of the bound location. The line nails on the straddles should protrude about 1/4" above the stakes. The stakes should be firm, but high enough to allow stringing above the bound location with enough vertical clearance for a plumb bob. Distances from the straddle nails to the bound points should be measured with a steel tape and recorded to hundredths of a foot on the inside face of each straddle stake. It is advisable, where bound points are located at a considerable distance from the center line, to leave additional tie stakes, in case the bound straddles are lost.

All bound points should be flagged, using a combination of green and white plastic ribbon.

303.4 SIDE-STAKING CENTER LINE

As soon as any construction line changes have been completed in given areas and all center lines have been rehabilitated, reference stakes (called side stakes) should be set at right angles to each 50-foot construction center line station. These stakes should be placed 30' beyond the slope line. (This will put the stakes 20' beyond the clearing line, where hopefully they can be saved.) In level country a right angle prism that has been checked for accuracy is a suitable instrument for turning of right angles to tangents and flat curves. Good judgment must be used,

however, in the use of this instrument. Generally speaking, the prism is not accurate enough for going out distances of over 125', except in wide-open flat country. Care should be exercised, when using a prism in laying out right angles to curves, that the tangent to the curve at a given station is first established as accurately as possible. On flat curves this can be done with reasonable accuracy by projecting a line thru two consecutive 50-foot stations on the curve to a point directly opposite the next 50-foot station on the curve. The offset distance to this station is then measured. One-half of this offset distance will then determine the offset distance to use for a sight point from one 50-foot station to the next, when laying out right angles.

Where the accuracy of the prism is in question, it is always best to use the transit. A transit can be a real time-saver in rough country, where vertical angles can be turned and slope distances measures.

Normally, side stakes should be set left and right of center line. In certain situations (e.g. where a side stake might fall in a driveway) it may be necessary to double-stake on one side only. Double staking should be used on the right of way side of double barrel highways when the median strip is going to be worked over during construction. There should be a minimum of 20' between double stakes, preferably 50' where practical.

A side stake should be driven into the ground two-thirds of its length, leaving a wide face parallel to the center line. The face seen from the center line shall be marked with the station and offset

distance, e.g., 72+50 over 192'. (See Plate No. 55.) A tall riser flagged with red plastic ribbon (blue or white on ramp side stakes) shall be set within 12" and directly behind each side stake.

Occasionally it is necessary to drive the side stakes flush with the ground, where they fall on a lawn or where there is extensive vandalism.

In urban areas, side stakes should not be set outside of the right of way, unless the Chief of Party has obtained permission from the property owner. Occasionally it may be possible to use red-flagged road nails for side stakes, such as in asphalt parking areas. Here again, property owners' permission must be obtained.

All side stake distances must be plumbed and measured carefully with a steel tape. Distances shall be checked after the stake has been driven to assure that the high corner of the stake is accurate. It is customary to set all side stakes to a full foot distance. Be certain, after the stake is in the ground that the offset distance and station are still showing, and that the distance on the stake agrees with the actual distance measured.

The Construction Division has issued an order to all Resident Engineers, that all survey stakes set by survey parties during the construction period be retained wherever possible for use in the taking of final cross sections. This is for roadway and pits.

Survey Party Chiefs will be held responsible to see that all survey stakes are removed from the project when the final roadway and pit cross sections have been completed. Any control points where stakes

are driven flush with the ground and cannot readily be seen may be left for future use should the occasion arise.

303.5 SIDE STAKE LEVELING

All side stakes must be leveled at the earliest possible opportunity. In wooded areas no attempt should be made to do any leveling until the trees and brush are removed. Generally, the most efficient method of leveling side stakes is to use two rodmen and two rods. This gives a minimum of delay between readings by the instrumentman. The rodman should carefully set the rod on the high corner of the side stake. Where possible, he should stand directly behind the rod, facing the transitman. In this way he can make the rod plumb and can accurately rock the rod 6" to the front and 6" to the rear. The transitman should carefully check his level bubble before each reading, pick the lowest reading obtained on the rod and clearly call it out to the notekeeper - calling each digit separately. The notekeeper should repeat the reading, and the rodman should immediately call out the station number and the offset distance left or right. Before leaving the stake, the rodman should make certain that the corner of the stake that was leveled is clearly marked with a dri-mark.

The notekeeper should record the level notes on looseleaf note paper, being careful to show the offset distances in the second column from the left. (See Plate No. 40.) In areas where the stakes are driven flush the notekeeper will have to refer to the notes showing the distances recorded at the time the side stakes were set.

All stake elevations and cuts and fills must be computed and then checked by another person in the survey crew. Then the backs of the stakes will be marked with the proper cuts and fills based on finished pavement grade. See Plate No. 55.

The most efficient procedure is to have one man reading the cuts and fills, two men marking side stakes, and the fourth man checking or figuring other stake notes.

303.6 RELOCATION OF BENCH MARKS

All bench marks that fall within the clearing limits must be transferred prior to construction. The transfer should be made before the bench mark tree is cut - even though the root with the spike and washers may still be in the ground. The tree roots will occasionally shift position when relieved of the weight of the tree. All bench mark transfers should have the letter "A" suffixed to the number e.g., B.M. 102-A. Use the bench mark book to record all B.M. transfers, and void all those bench marks that have been destroyed.

If a U.S.G.S. or a U.S.C. & G.S. disk is found to be in the construction work area, take a disk rubbing, record a description and send it to the office of the Location Engineer. The Location Engineer will request a "Reset" disk from the proper Government Agency. While awaiting the arrival of the new disk a temporary bench mark should be set and leveled with second order accuracy and the old disk removed and forwarded to the Location Engineer. When the new disk arrives it should be carefully set in a permanent location that will not be affected by frost. The survey crew will establish the elevation of the "Reset" disk

with second order accuracy, i.e., with rod readings to thousandths, using a rod target vernier. Rod readings should not vary over two-thousandths on the double rodded H.I.'s. The Survey Party Chief should write the description for the new bench mark, pinpointing it by physical features, in a manner that any stranger can readily find it. A special form will be provided by the government agency for the level notes. The same set of notes shall be recorded in the bench book. The level notes on the special form shall be forwarded to the office of the Location Engineer for processing to the proper government agency.

303.7 RESECTIONING ORIGINAL ROADWAY SECTIONS

Occasionally there will be areas where excavation or fill has changed the contour of the ground since the original roadway sections were taken. New original cross sections must be taken in these areas prior to construction (supersede original cross sections). Department policy does not allow the taking of original roadway cross sections from construction lines in areas that were covered by original cross sections referenced to a survey line.

STRUCTURE LAYOUTS

On a construction project where one or more structures are to be built, the survey crew will be furnished with a 50 scale set of bridge plans. Generally, a survey layout sketch is incorporated on one of the plan sheets for each bridge. If not, a suitable layout must be developed from the plans. The Survey Party Chief will obtain the Project Engineer's approval for the proposed layout. Occasionally, field conditions may warrant a change in the normal layout procedure. However, every layout, even if only a partial layout, must have a triangulation check.

The Survey Party Chief will make a layout sketch in the field notebook. Use as many pages as needed to show all of the required information. It is important to show the bridge number and description and the stations and angles of crossing to the center line or center lines of construction. Use the following steps for bridge layout procedures: (See Bridge Layout Plate Nos. 34-37, incl.)

1. Make Layout Sketch as shown)
2. Transfer Plan Measurements)

By:_____

3. Transferring of figures from Plan and Schematic Sketch)

Checked by:_____

4. Make Bridge Layout according to sketch.
5. Show how you laid out given angle between center line of bridge and center line of bearings. Number of times turned, etc., clockwise angle only.

6. Show type of chain used such as steel canyon, calibrations given, and computations for temperature correction and pounds pulled for all distances laid out.

7. All computations and layout procedure checked by Project Engineer, _____. By: Survey Supervisor, _____.

8. Overall check by Location Engineer, _____.

It should be noted that the layout must be developed independently by the Chief of Party and recorded in the field book with his signature. The transitman should independently check the layout as developed from the plans and indicate by his signature that he agrees with the Chief of Party. All computations and layout procedure must then be checked by the Project Engineer. The Survey Supervisor will also independently check the layout. He will obtain a check of the triangulation from COGO. When the layout sketch has been completed and all field measurements, plan measurements, and COGO triangulation results clearly shown, the Survey Supervisor will add his signature on the layout page and immediately forward the book to the Location Engineer for his overall check and signature. Xerox copies of the layout pages in the field book will be kept on file at the Office of the Location Engineer and the book will be returned to the project field office within 48 hours.

The purpose of the independent checks is to avoid costly mistakes. The accuracy needed in all field measurements cannot be over emphasized. This is especially true where multiple span structures are involved. The normal tolerance in diagonal check measurements should not be over 0.02 of a foot. In long structures across streams it may be preferable to use a

geodimeter to check the spans and diagonals. The diagonal distance checks are very important, but angle checks are also helpful in determining errors in layout.

When laying out angles from center line of bridge to center line of bearing, it is important to use the longest sights possible and to wind up the angle with a minimum of four turns for a check, alternating with the telescope direct and inverted. Do not allow the average of the turns to be off more than a few seconds. Any slight skew in the center line of bearings means trouble in the triangulation check.

Once the center line of bearing is established on one side of the center line of bridge, intermediate tie points should be set on the same line of sight. After the tie points are all set on one side of the bridge, new line of sight should be taken on the furthest sight point and each point carefully checked. Any slight variation must be corrected. It is customary to use brads to mark the line on the stakes. These can easily be removed with pliers and shifted slightly. The tops of the brads should be allowed to project about one-sixteenth inch above the stake to provide the opportunity for shifting location on the stake and to allow for the swelling of the wood when the stake gets damp. It is helpful to circle the brad with a Dri-mark.

To establish the sight points on the same center line of bearing on the opposite side of the center line of bridge, the preferred method is to set the transit on one of the outermost ties just established, to then take line on the point just occupied on the center line of bearing at the

center line of bridge and to double-project this point to set a tie point a maximum distance on the opposite side of the center line of bridge. Double-projecting uses the same principle as double-centering, but does not necessitate flopping the telescope in the opposite direction after taking line. Intermediate tie points can now be set. Where possible, all of the points now established along the center line of bearing should be checked from one set up, by taking line from one outside point to the opposite outside point and making sure that each intermediate point is on a perfectly straight line.

All distances must be measured with a calibrated bridge tape, using scales and grippers. The proper pull and properly applied temperature correction are extremely important. The temperature correction may be taken from the table shown on Plate No. 63. The level of the tape should also be checked with a hand level before each measurement. Every tape measurement should be checked and double-checked for accuracy.

Where wing lines are laid out on skew angles, the accuracy of the layouts should be checked with additional diagonal measurements to the ends of the wings from the nearest center line of bearing at the center line of bridge.

When bridge targets are used, it is important to have a hub tie within a few feet of the target. This will allow the Project Engineer to accurately check the target to see if it has been disturbed.

All bridge tie hubs shall be driven flush with the ground, with reference stakes clearly marked for each hub. "Bull pens" made with

risers and spaced far enough apart to allow the setting up of a transit between them, shall be set around each hub. The "bull pens" shall be well outlined with yellow plastic ribbon. Bridge targets shall be nailed onto rugged frames, well-braced and firmly attached to permanent objects or driven firmly into the ground. With the small bridge targets, it may not be necessary to make an elaborate frame.

The preliminary bridge layout will include ties and targets as requested by the Project Engineer along the center line of bridge, the center line of bearings for the abutments and piers and along the working lines for the wings. The center line of bearings and the center line of bridge should have a minimum of three ties each side of the location of the structure. There should be three hub ties for each skewed wing.

Following the complete bridge layout, a survey crew may be called back to replace ties or to check spans after the concrete has been poured. The survey crew is usually asked to scribe center line of bearing on the pads and scribe line for the center line of bridge. The Project Engineer will set his own grades on abutments, piers and footers. He will also replace center line, check camber on steel or camber for concrete superstructure, and alignment for bridge rail and the like.

305 SECTIONS FOR STRUCTURE EXCAVATION

Structure excavation is paid for as a separate bridge item; therefore the survey crew, upon completion of a bridge layout, will be asked to take cross sections for excavation for the footings of abutments and piers. The base line used for these sections is the same base line

as used for the layout of the abutments and piers, i.e., the center line of bearing or the face of abutments. Cross section coverage must be well beyond the limits of construction. A section will be taken to cover every angle point on the footing for the abutments, wings and piers. In ledge areas it may be first necessary to take sections for earth structure excavation. Then after the ledge has been exposed, it may be necessary to take sections from the same stations for ledge structure excavation. A layout sketch or sketches must be in the field book to show the layouts for structure excavation for each abutment or pier. A separate book should be used for each structure. This book would include the structure layout, the ties, T.B.M. transfer information and structure excavation sections. Two T.B.M.'s established for the bridge should be set at a convenient location to be used during construction. The elevation should be set by running a double-rodded line from an established bench mark thru the T.B.M.'s to another established bench mark beyond the structure. The T.B.M. elevation should then be adjusted to fit the best average between the two bench marks.

306 SECTIONS FOR LEDGE EXCAVATION

Where ledge is classified, i.e., a bid price is set for ledge excavation, the survey crew will be asked to take original sections on all ledge after it has been exposed. All sections will be referenced to the center line of construction. If the ledge is reasonably uniform, good results will be obtained by taking sections from stations a maximum of 25 feet and a minimum of 10 feet apart, with rod readings taken at

right-angles to the construction line at all breaks. Care should be used, since the prices for classified ledge excavation run high. The Survey Party Chief should refuse to section any ledge that is not properly stripped. On ledge that lacks uniformity, small pockets of unstripped ledge will occasionally be found. The Survey Party Chief will not section this ledge unless the contractor furnishes a man with a hand shovel to expose the ledge in the questionable areas. In the interest of accuracy, if drill rigs are actively working in the area to be sectioned, the contractor should be asked to shut down the rigs briefly until the sections have been completed thru the immediate work area. Under nc circumstances will a survey crew take ledge sections on ledge that has been activated for detonation.

The cross sections will be taken with at least one shot shown beyond the exposed ledge. All rod readings taken on exposed ledge will be labeled with an L shown just above the offset distance. A zero section will be shown at the beginning and end of each ledge area.

On jobs where ledge is bid unclassified, i.e., where ledge is paid for on the same price basis as earth excavation, the survey crew may be asked to take original ledge cross sections at every 50-foot station in the ledge area. The purpose of these sections is to give a quantity basis for over-breakage or when a sub-contractor is involved. Over-breakage is paid for under a separate item. (See Plate No. 39.)

307 SECTIONS FOR MUCK EXCAVATION

Where there is a separate item for muck excavation, normal sections from every 50-foot station will be taken following the excavation. Sections will be carried out to old ground, with the shots actually taken on muck clearly labeled with an M above the offset distances. Zero-out stations must be shown at the beginning and end of the muck area.

308 BORROW PITS

Pits may be classified as Borrow Pits or Gravel Pits, or a combination of both, but the following instructions apply to all pits:

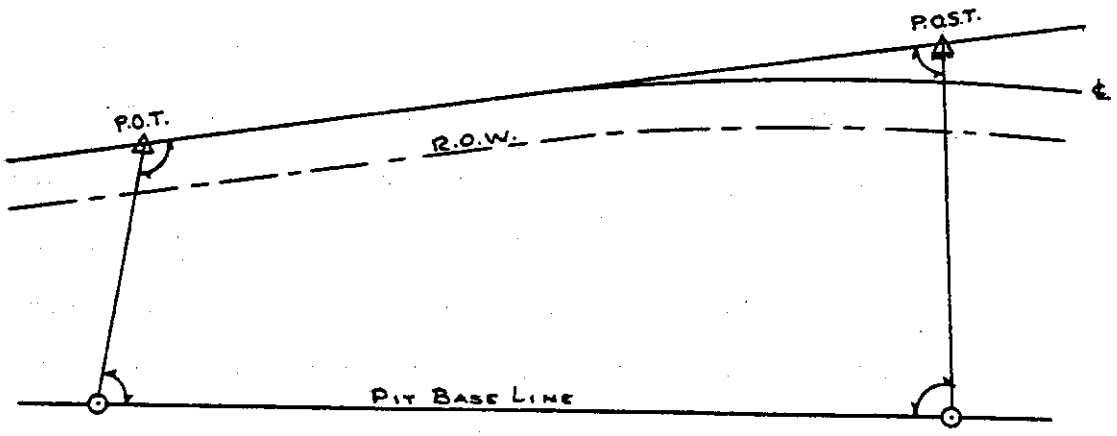
308.1 FIELD WORK

1. Pit sections are to be taken 25 feet apart, except that in uniformly flat areas, where borrow is to be excavated by belly-dumps, it may be practical to take 50-foot sections. If considered absolutely essential, certain odd sections may be taken, but in general the minimum 25-foot distance will be considered to be within the accuracy required. Any odd sections required must be full length sections. Odd shots or part sections, taken between sections here and there, intending to show high or low spots or local limits, will not be acceptable.
2. Give complete description and/or sketch of pit location, together with correct names and addresses obtained from the Project Engineer.

3. In case of adjacent ownership, the Project Engineer in conjunction with the Contractor and the land owners, will locate the property line ties and inform the Survey Party before any material is removed.
4. The Survey Party Chief will check and cooperate with the Project Engineer so that all the information necessary for the records is properly and accurately recorded, prior to the beginning of any phase of the work.
5. For suggested layouts, for roadside pits, see the samples following these instructions. See also Plate No. 41 for a pit layout.
6. Begin Base Line Stations at 40+00 or 50+00 and begin offset distances with a large enough figure to avoid minus distances should the pit be extended back to the left. All pit sections must be to right.
7. Radial Sections, Roadside Pits - If the main road center line is on a curve, carry radial sections out to the Right of Way Line and then set up remainder of pit with parallel sections, as per the sketches.
8. Pits within 500 feet of the main road must be tied into the center line of construction; with the base line either parallel or at right angles to the tangent or the subtangent.

Engineering Audit needs to have you start with the Roadway center line when a pit base line is to be tied to the roadway center line, since the roadway center line has been plotted and the right of way line given in

relation to that center line. Two such ties are needed to accurately plot the pit base line on the plan sheet which shows the roadway center line.



PROCEDURE

Set on these points (not merely on points on pit base line).

Record the Roadway stations.

Measure and record the angles and distances to points on pit base line. (90° angles usually best if practicable.)

Measure and record the stations of those points on the pit base line.

Measure and record the angles as a check.

In addition to the horizontal ties to the center line of construction, the pit elevation datum must be tied to the same datum as used on the construction project.

9. It is important to use good judgment in locating a pit base line so that it will not be lost if the pit is extended; and so that the sections will cross as many

vertical faces as possible at right angles. The base line should be tied out in at least two areas in a big pit. Bench marks need to be located in areas where they can be saved. Have at least two bench marks in each pit in case one or more is destroyed. Bench marks should be carefully described and referenced to the grid base line. The pit layout sketch should show the approximate location of the road coming into the pit, with ties to the nearest highway and an approximate distance to an easily found landmark. An observed compass bearing along the base line and an approximate north arrow should be shown on the sketch. The approximate pit limits should also be shown.

10. Grid lines should be run no more than 200' apart across the stripped area of the pit, using a transit and steel tape. Every 100' along each line a stake should be accurately set, with line and distance indicated by a nail. The 100' stakes should be marked with the station and offset, (e.g. $\frac{53+00}{R-400}$). The marking should be on the face that will be seen when progressing ahead station-wise. Intermediate stakes may be set approximately on line and distance. They should be turned sideways and need not be marked with the station. When the sections have been completed, the intermediate stakes should be salvaged to use elsewhere.

11. When the pit area has been adequately staked out, sections will be taken at 90° to the base line, with rod readings

every 25', plus additional shots as necessary to show the contour of the ground. Distances will be measured with a cloth tape and rod readings for ground elevations recorded to the nearest tenth (0.10) of a foot.

12. Survey crews will be supplied with a distinctive marker to outline all pits. Material will not be taken until these markers have been erected.

308.2 USE OF BOOKS

1. Books containing notes on other phases of the project - detail, etc., shall not be used to record pit sections. There will be one pit only, originals and finals, entered in a book which is assigned to a project while that project is active. This will allow the book on any one pit to be sent to be processed when the finals have been completed on that pit, without delay. It will also simplify the key-punching operation. These books may be used at a later date for other projects after the original project is entirely complete and final payments are made.

308.3 NOTES IN FIELD BOOKS

1. Do not use a pencil that is too hard, but a 2H or 3H. Avoid extremely small figures. Legibility is a MUST. Readable notes can be key-punched at nearly 10,000 characters per hour. Make all figures so that operators

do not have to give them a second look, in the interest of time and accuracy. Use plenty of space.

2. To avoid possible question as to which H.I. goes with which set of notes, always leave two spaces between T.P. computations (vertical control notes) and the next line of notes. Leave at least three spaces between one station and the next.
3. Direction of sections must be from left to right and shots must be entered in the notes from left to right. Shots must be started in the fourth column of the left page and entered in blocks of nine with a line or space left between blocks. Enter no more than 18 shots per line. On adjacently owned pits, when the shot at the P.L. is taken, leave a space and start another block of nine or less.
4. Enter full station number at left of each line of notes and enter actual complete distances, 500 525 550 560 575 600, etc. NOT 500 25 50 60, etc.
5. Do not use more than one H.I. on one line.
6. All level notes are to be checked before books are released and the notes are to be checked off in the book to indicate the fact. Show page reference on right hand page wherever B.M. elevations are cited. If the roadway datum is used, show the book number or mark "Per Plans" as applicable.
7. No Hand Levels to be recorded on any pit.

8. When the sequence of shots on any one station at any one H.I. needs to be broken, do not enter all shots on one line. Use a separate line for each sequence.

EXAMPLE

Do not enter:

$45 + 25 \quad \frac{500}{10.0} \quad \frac{525}{8.0} \quad \frac{550}{7.0} \quad \frac{590}{6.0} \quad \frac{600}{8.3} \quad --- \quad \frac{700}{7.0} \quad \frac{725}{6.0} \quad \frac{750}{5.0} \quad --- \quad \frac{900}{8.0}$

Enter:

$45 + 25 \quad \frac{500}{10.0} \quad \frac{525}{8.0} \quad \frac{550}{7.0} \quad \frac{590}{6.0} \quad \frac{600}{8.3}$

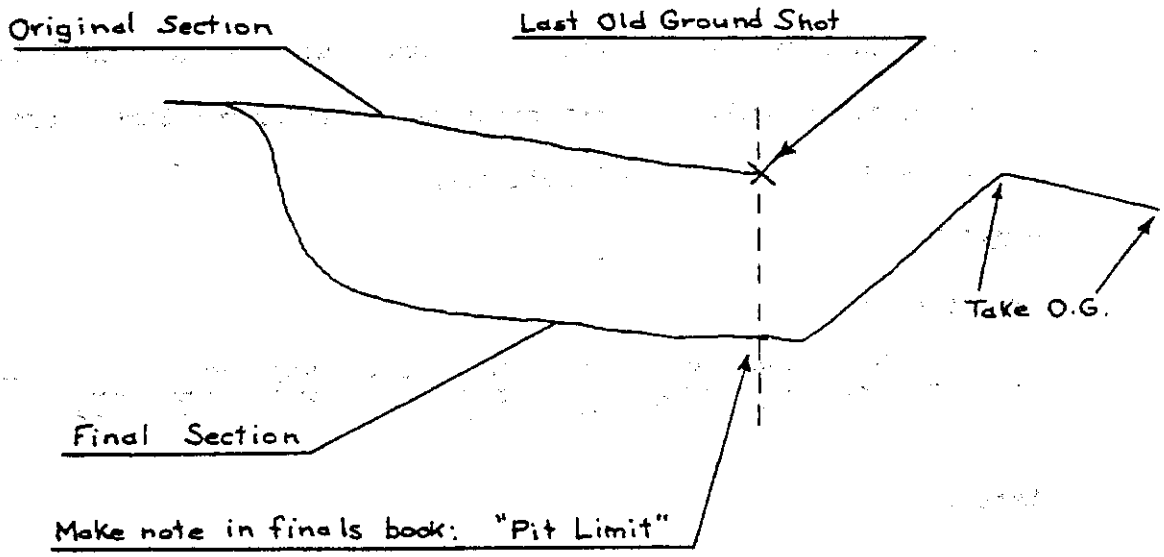
$45 + 25 \quad \frac{700}{7.0} \quad \frac{725}{6.0} \quad \frac{750}{5.0}$

$45 + 25 \quad \frac{900}{8.0} \quad \frac{825}{5.0} \quad \frac{950}{7.0}$

The above indicates to the key-punch operator that 3 separate cards are to be used, which will allow the machine to sort other cards, (between 601 and 699 and 751 to 899), into their proper numerical sequence. (See Plate No. 42 and 43.)

9. Take shots and label them at match lines, R.O.W. lines and other property lines in both the original notes and in the final notes.

10. In Pit areas where excavation has exceeded the pit limits as set, final shots should be taken at the distance of the last original and marked "Pit Limit," (Not "P.L."), and the shots continued to positive old ground as in the sketch.

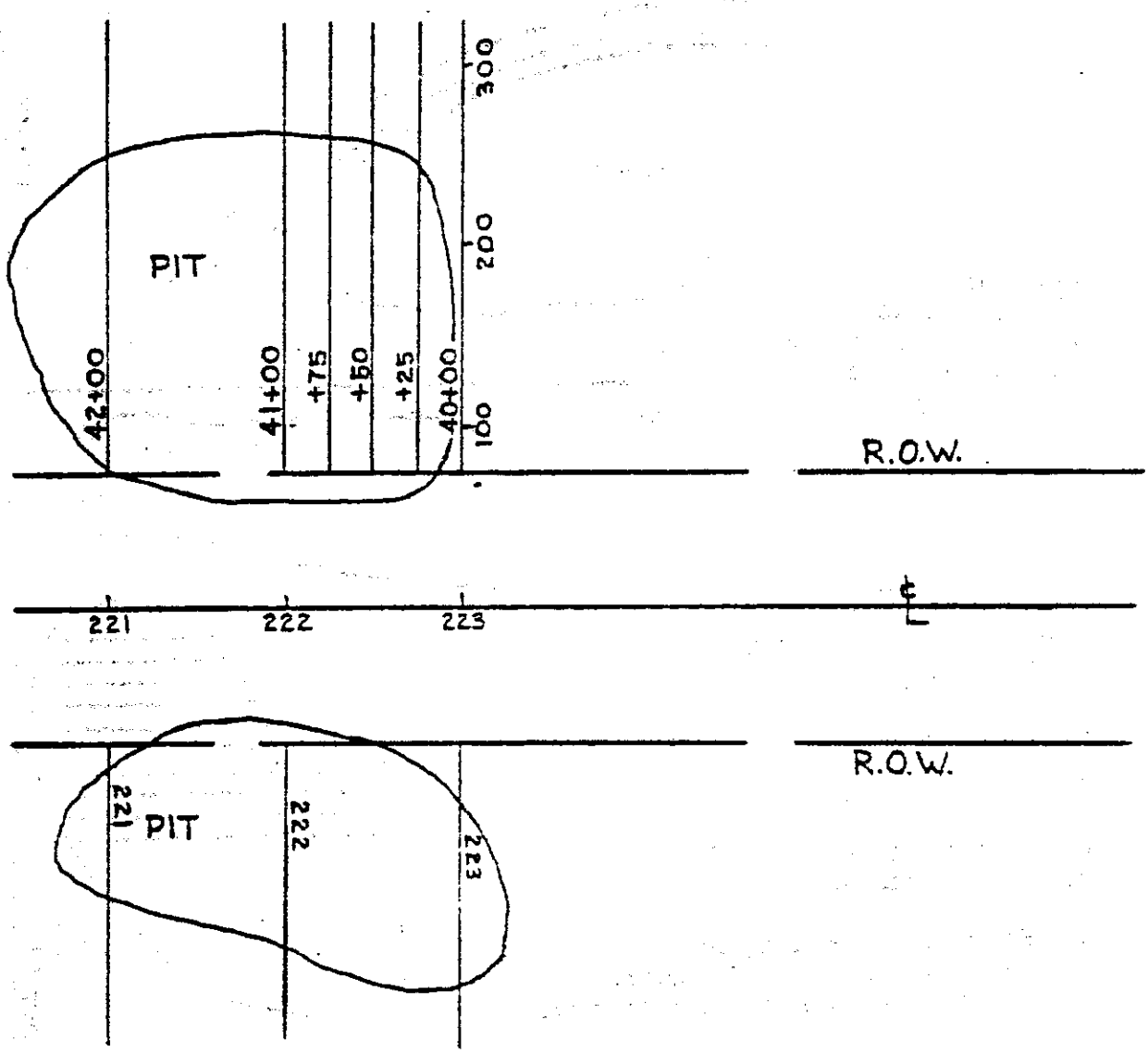


11. Do not leave overlapped sections in the book. Cross out the shots taken when the contractor has pushed the strippings back to extend the pit and the shots are no longer valid.

12. The tolerable error of closure vertically between original and final shots may be from 0.0 to 0.5 feet. The largest percentage of shots, however, should check out closely, verifying the accuracy of the work. Should there be any indication of a consistent error of closure in one direction, even within the quoted tolerance, indicating that something is wrong, proper action should be taken to find the discrepancy.

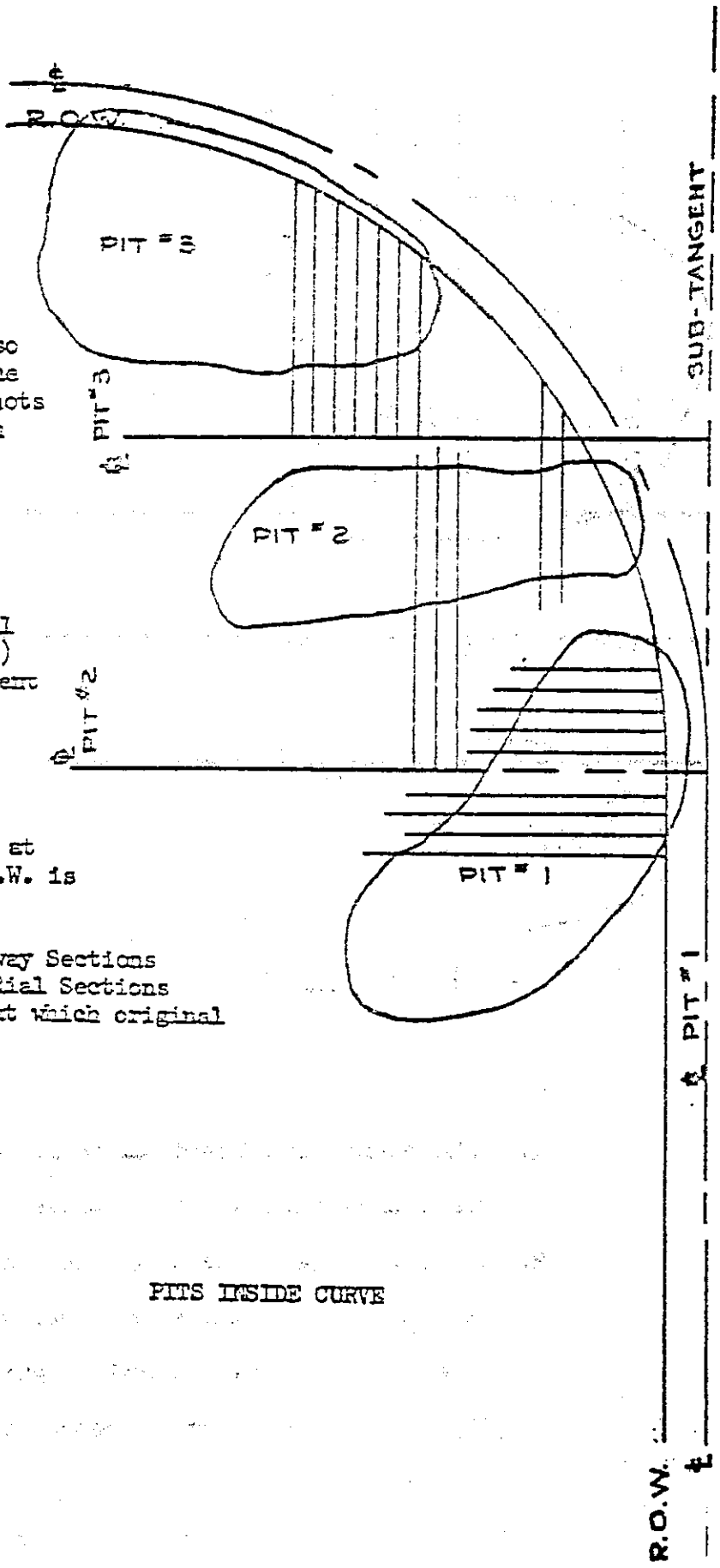
308.4 PLOTTING PITS

1. Pits will NOT be plotted in the field. All pits will be taken so that they may be computed by Electronic Computer in the Concord Office.



1. Take roadway final sections to R.O.W. line at the same stations at which original roadway sections were taken.
2. Use roadway center line as base line for pit sections, and take pit sections at 25' intervals. Shots at R.O.W. line are to be taken on both original and final surveys. (The R.O.W. line becomes a match line.)

ROADSIDE PIT ON TANGENT SECTION



Base Line to be set so that pit is all on one side of it and the shots will be recorded from left to right.

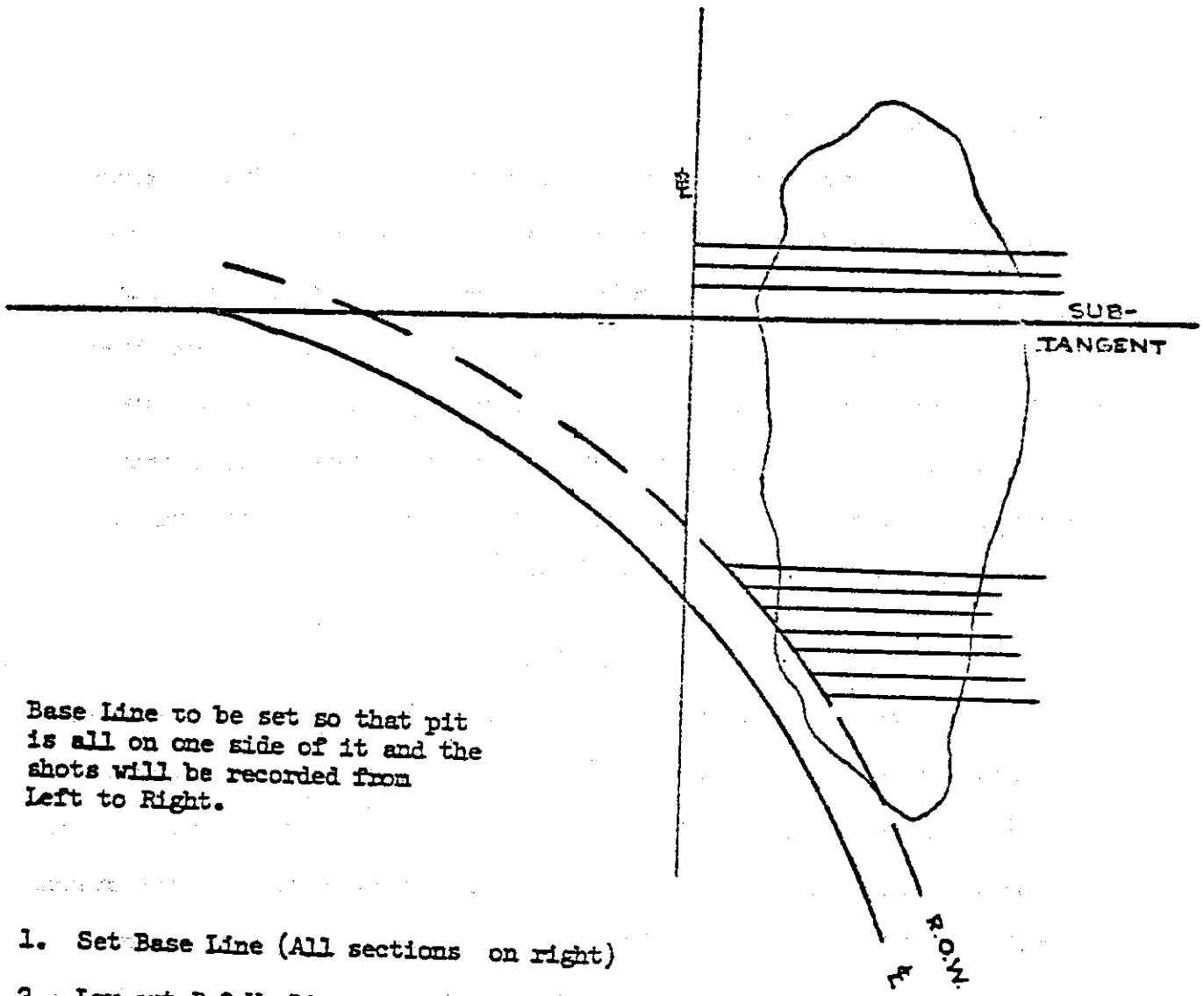
1. Set Base Line (all sections on the Right) perpendicular to Tangent as Base Line.

2. Lay out R.O.W.

3. Take original and final shots at R.O.W. at each station (the R.O.W. is now a Match Line).

4. Extend Final Roadway Sections out to the R.O.W. (Radial Sections at the same Stations at which original sections were taken.)

PITS INSIDE CURVE



Base Line to be set so that pit is all on one side of it and the shots will be recorded from Left to Right.

1. Set Base Line (All sections on right)

2. Lay out R.O.W. Line

3. Take original and Final shots at R.O.W. at each station. The R.O.W. is now used as a Match Line.

4. Take Final Roadway Sections out to the R.O.W. (Radial Sections at the same Stations at which original sections were taken.)

PITS OUTSIDE CURVE

308.5 GENERAL NOTES

All pit books may be left with the Project Engineer, except during the winter, between the time the originals are taken and the finals completed. When the Project Engineer releases the book upon the completion of the pit, the book is to be transmitted by the Chief of the Survey Party to the Area Supervisor or to the Office of the Location Engineer. Upon suspension of the work, Project Engineers have been instructed to return all books to the Area Supervisor, or to the Office of the Location Engineer.

309 WASTE AREAS

During the construction stage there may be excavated material classified as waste. This material may be deposited in an area approved by the Project Engineer. It may be placed within roadway sections or in a pit. Original sections must be taken to show elevations of the ground prior to the deposit. When the waste is placed in an area that was sectioned prior to construction, the originals for waste will in effect be semi-finals for the particular roadway area or pit area. Therefore the sections must be taken from the original base line. Then the finals will give the quantity of the waste deposit.

310 STAKES AND GRADES DURING CONSTRUCTION

At various stages during construction the survey crew may be called upon to give grades. In deep cuts or high fills where the original side stakes become difficult to use, the survey crew may be asked to

reproduce the center line. The contractor may then set his own tall grade stakes from this line. The survey crew may be asked to give grades on these stakes.

The contractor may call for grades on his own stakes several times during construction, but generally it will be only once during the final gravel stage. The survey crew will generally be asked to set cuts or fills to the nearest full foot to finish profile grade. The elevation will be marked on the stake with a "Dri-marker." A horizontal mark indicates finished grade elevation. $\overline{\times}$ indicates a fill and the amount of fill must be shown, (e.g. F-1'). $\underline{\times}$ indicates a cut and the amount of cut must be shown, (e.g. C-2'). The amount of cut or fill must be marked on the face of the stake.

Occasionally the survey crew may be asked to replace and level original side stakes that have been knocked out by the contractor. A record should be kept of the number of stakes that have to be replaced. A tally should be sent in on the daily report cards, listing the number of stakes that were replaced within a given station to station section, and time involved.

312 LAYOUT FOR CURBING AND SIDEWALKS

A survey crew may be called upon for curbing and/or sidewalk layout. Where blue tops are run, curb alignment and grade may be obtained from the blue tops. In cases where blue tops cannot be used, it is customary to set survey stakes on a 5-foot offset line to the curb. Radius points for islands will be set according to the plans. When laying out

islands the curbing layout alignment should be checked in the field by swinging the radii to see that there is no break in the alignment of the face of curb. The survey crew may level the offset stakes and mark the stake elevations on the stakes. The Chief of Party will not figure grades for curbing. If the Project Engineer wishes to give the grades to the survey crew, then the survey crew can mark the cuts and fills if the Project Engineer so requests.

313 STAKING FOR UNDERDRAIN

The survey crew may occasionally be asked to stake out underdrain. Usually one line of 10-foot offset stakes is used, with stakes set every 25' on line. The stakes should be leveled and the stake elevation marked on the stake. Usually the Project Engineer will figure his own cuts from the stake elevations.

315 LAYOUT FOR FENCING ALONG RIGHT OF WAY

When right of way fencing alignment is required, it is customary to lay out the computed angle with a transit that will give the computed right of way bearing from one bound to the next. In heavily wooded areas the survey crew will place risers flagged with green and white plastic ribbon along the right of way line for about 200' in each direction from the bound. When the fence clearing crew has brushed out the line, the survey crew may return and give good line for the fence. Survey stakes, marked R/W will be set along the line at approximately 100-foot intervals. A riser flagged in green and white plastic ribbon shall be set beside each survey stake. If, in the opinion of the Survey Supervisor,

the survey crew can lay out the line for brushing and then with a minimum of delay follow immediately behind the brushing crew with stakes for fencing, he may give permission to proceed in this manner.

317 ESTABLISHING GRADES FOR PAVEMENT

There are several ways currently being used for establishing grades for pavement. The setting of "blue tops" is the most used method. In this method the contractor furnishes the oak hubs and the survey crew sets them to finished gravel grade. After leveling, the tops of the stakes are painted to make them conspicuous for the grade foreman. In normal sections, blue tops will be set at center line and 12' left and right. Where there are truck lanes or incoming ramps involved, additional blue tops on each station may be required. Blue tops should not be set unless the gravel is within two or three inches of finished gravel grade. Blue tops are not to be set more than once. If the gravel is not properly compacted, they should not be set. The contractor should drill the holes for the stakes and should furnish a man to help drive the stakes to grade.

On city streets blue tops may not be required. Gravel stakes may be sufficient. The method used in this case is to run an offset on one side of the road, along the shoulder break. Standard survey stakes are set accurately for line and distance at each offset station. These stakes will be leveled and marked with a cut or fill to plan profile finish grade.

Many contractors are now using the C.M.I. machine or its equivalent instead of blue tops. A row of offset stakes is run accurately on each side and the elevations of the stakes are established by the

survey crew. The elevations on the offset stakes are utilized to establish the proper elevations of the sensor guide wire.

320 CENTER LINE FOR PAVING

It may be required to run center line on any of three stages. The stages are as follows: tack coat, completed base and final course. If practical, the blue tops are sometimes used for the alignment on top of the tack coat (in cases where the blue tops can be seen through the oil). Where the line is run on the tack coat, most of the Project Engineers are establishing their own offset stakes or offset nails for their center line on top of the base course. The survey crew will be required to run center line on the final course. Blank nails (not flagged) will be used on center line every 50'. A small spot of paint should be made directly in front of each nail for a guide to stripe paint the center line. The station may be painted in the road in small figures every 500'. There will be no other painting of stations.

321 STRIPING ON RESURFACED PROJECTS

Survey crews may be requested to spot paint center line for painting on pavement that has been resurfaced. Spots of paint should be marked on the pavement splits at approximately every 50' on curves and every 100' on tangents. The curves need be marked only on Interstate Highways. The spot painting on all of the tangents should be lined in with the transit.

322 DEVIATIONS FROM ESTABLISHED PROCEDURES OR POLICIES

Whenever there is any deviation in layout work covered by specific instructions previously issued by this office that is requested by the Resident Engineer or his representative, it is imperative that the Party Chief appropriately document theprocedure followed, indicating all deviations and under whose instructions such deviations were made. Also, within twenty-four (24) hours, the Party Chief shall contact the Area Survey Supervisor, or the Location Engineer to advise him of the deviations and to receive further instructions.

FINAL SURVEYS

SECTION IV

FINAL SURVEYS
SECTION 400

FINAL SURVEYS

INDEX

Approved _____

Date _____

400 GENERAL

A Final Survey is made of a project to determine earthwork quantities and show graphically the location of the constructed roadway compared to the construction plans. Survey's function in final surveys is to provide the roadway center line, pit and roadway sections, limited drainage and bound location.

Finals will be taken on all Federally funded projects which involve earthwork. On State funded projects the Survey Supervisor will check with the Construction Engineer as to the necessity of final sections.

Often during the construction phase there will be opportunities to take finals in ledge areas, pits and where sections later may be difficult to obtain. If a center line is available a discussion by the Party Chief with the Survey Supervisor should determine the appropriate action.

Final surveys should be completed within 20 working days from acceptance of the project by the Construction Engineer.

410 ALIGNMENT

The final center line, which often is rehabilitated under the construction phase to stripe paint the pavement center line, must be reproduced accurately to agree precisely with the location used during the preliminary or construction survey. In most instances, where line changes are made during the design phase and right-of-way is referenced to the roadway center line, only the construction line need be established. Should the right-of-way be referenced from a survey line both the construction and survey line may need to be reestablished. All control points, i.e. tie points, bound locations and alignment control, will be accurately set using stubbies and prick punch. The actual distances between control points will be recorded. Most times, the final distance will be less due to the elimination of obstacles and uniformity of terrain.

Dunbarton P-3639-C

Final Alignment Rte 13 Reloc.

E. Chase
R. Dubriske
E. Ford
D. Richards

30 Aug 1953
Cloudy & Humid
Lt. Showers (65°±)

3

Const. Alignment	Bk. 6906, pg. 6-18 Bk. 7001, pg. 54-56
Ties	Bk. 7002, pg. 27-39
R.O.W. Bounds	Bk. 7003 pg. 50-58

The above information was used to reproduce the FINAL alignment.

Reference all information used to reproduce the final alignment.

The final alignment sketch will show all actual measurements between control points compared with initial layout.

When angles and measurements are repeated show all repetitions and indicate the value to be used.

46+50.00 (As Tied)

Goose Cr.

MEAS. 307.63

78°-16'-30"

USE 78°-11'-45" MEAS
156°-23'-30"

MEAS
50.03
50.00

P.C. = 43+42.37

542.15

P.O.T. = 38+00.00 (As Tied)

399.82 MEAS.

P.O.T. = 34+00.00 (As Tied)
Begin

3/15/77
410.2

FINAL SURVEYS

420 CROSS SECTIONS

Final cross sections should be taken at all full and 50-foot stations. The final roadway section will show all ground break points, center line and edge of pavement only. The typical section will be used as a guide only. Final sections shall be extended on each side of the center line so that the last two readings at each end of the section will be original ground elevations and appropriately marked "O.G." The shot marked edge of work (EW) is also old ground but for the purposes of the manual will not count as an old ground shot. In a like manner, descriptive notes or abbreviations should be placed over any shots where your comment may be helpful to Engineering Audit personnel. Where a discrepancy is noted, give an adequate explanation. A few comments may save several hours by Engineering Audit personnel. All explanations will be in brackets as shown: { }

Any abbreviation which is not common or questionable should be written in full where first used, i.e.

STONE FILL	SF	SF
36	40	44
3.8	5.9	5.8

Since final cross sections are used to determine "fat slopes" and accuracy of a hand level can be debated by the Contractor, hand levels will not be used in taking finals.

Checking old ground elevations on original sections against final old ground elevations is time consuming and will be done by Engineering Audit personnel if necessary. In many cases final sections are not taken at the same location as the originals and only when several sections are compared can a reliable judgement be made.

In areas where grids were taken or original sections are referenced from the survey center line, final sections will be taken about the construction center line at even fifty-foot stations.

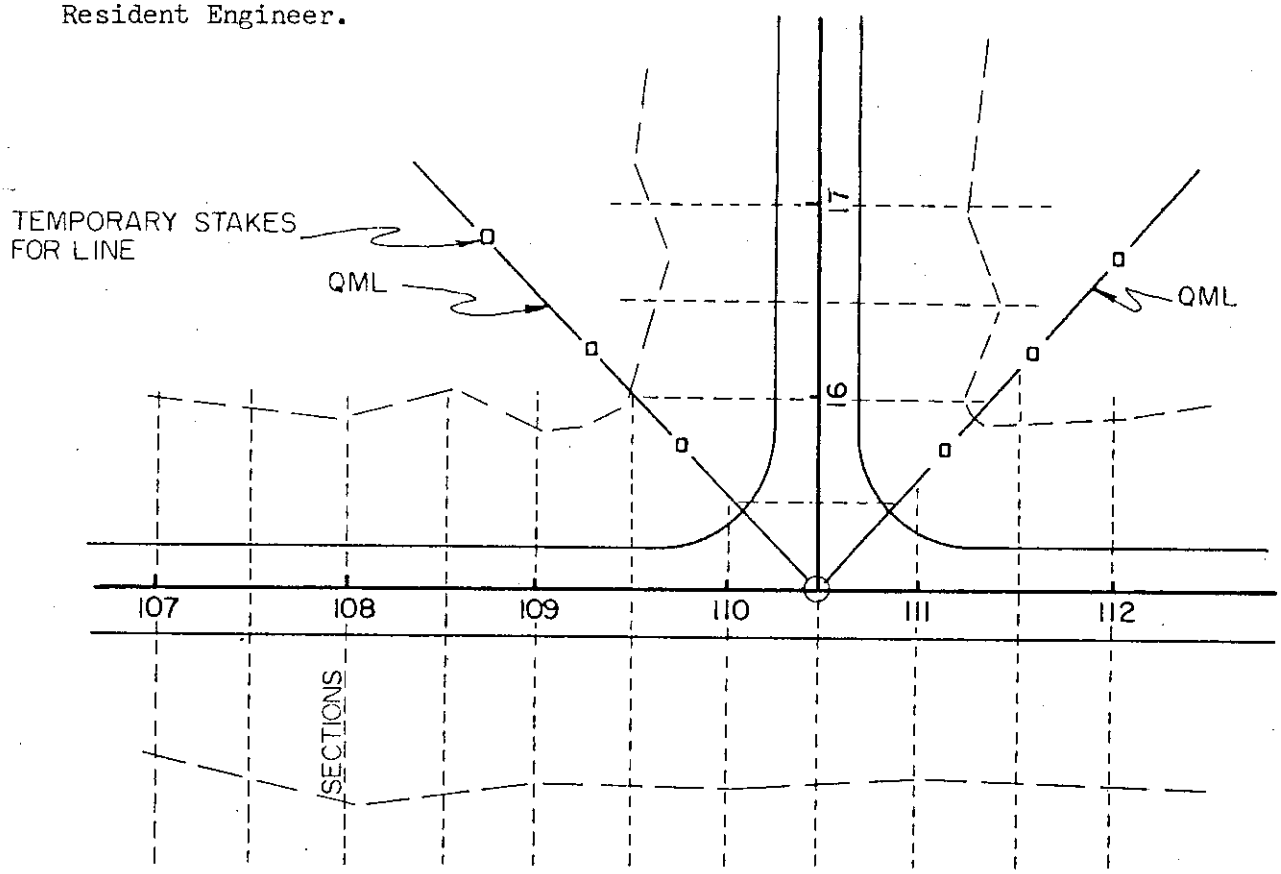
FINAL SURVEYS

Whenever using a Quantity Match Line (QML) for complete coverage, be sure the Quantity Match Line is staked out to accurately establish the last elevation shot.

When stone lined (SL) ditches are encountered in the final section, the beginning and ending ditch limits need be shown by Plus and Offset only and there will be no need for an odd section. Show the limits of stone fill on each section as it crosses the ditch.

Guardrail (GR) should be noted only in the normal roadway sections.

Final sections should extend across stump dumps or waste areas adjacent to the roadway unless it is determined as unnecessary by the Resident Engineer.



QUANTITY MATCH LINE

3/15/77
420.2

Dunbarton P-3639-C

Final X-Sections Rte 13

E. Chase
R. Dubriske
E. Ford
D. Richards

2 Sept. 1953
Clear & Sunny
(70°±)

3

BM #30	15.00	372.17			357.17
TP #1	11.36	382.16	1.37	370.80	
38+00					
	Stone Fill (SF) begins 37+95±				
38+14	Outlet				
	Obtain profile of thread of ditch on all inlet or outlet pipes not in the final roadway cross sections.				
38+26	Inlet				
38+50					

Elev. Bk #6954, pg. 30

38+20, Lt 37' sta

			EP			
36	30	82.5	22			
9.8	7.6	7.6	7.1	7.1		
	QML					
68	57	40	38			
9.1	9.6	10.0	10.7			
			INV RCP			
			40			
			3.6			
			EP			
Cont. 38		82.5	22			
pg. 9	9.6	9.5	8.1	7.5		

	EP				Lt.
	22	38	53		68
7.7		9.7	8.0		7.8
		DITCH →			
SF	SF	SF			EW
65	70	75			85
9.0	9.3	7.5			6.5
OG	OG				
95	107				
6.0	5.8				
INV RCP	Skewed Outlet ditch →				
50	80	100			127
4.9	5.0	5.3			6.2
OG					
135					
6.7					
			← DITCH		
EP			SF		
32	37		61		Cont.
8.0	9.9		7.5		pg. 9

FINAL SURVEYS

4/29/77
420.3

Dunbarton P-3639-C   E. Chase & Crew   2 Sept 1953   **4**

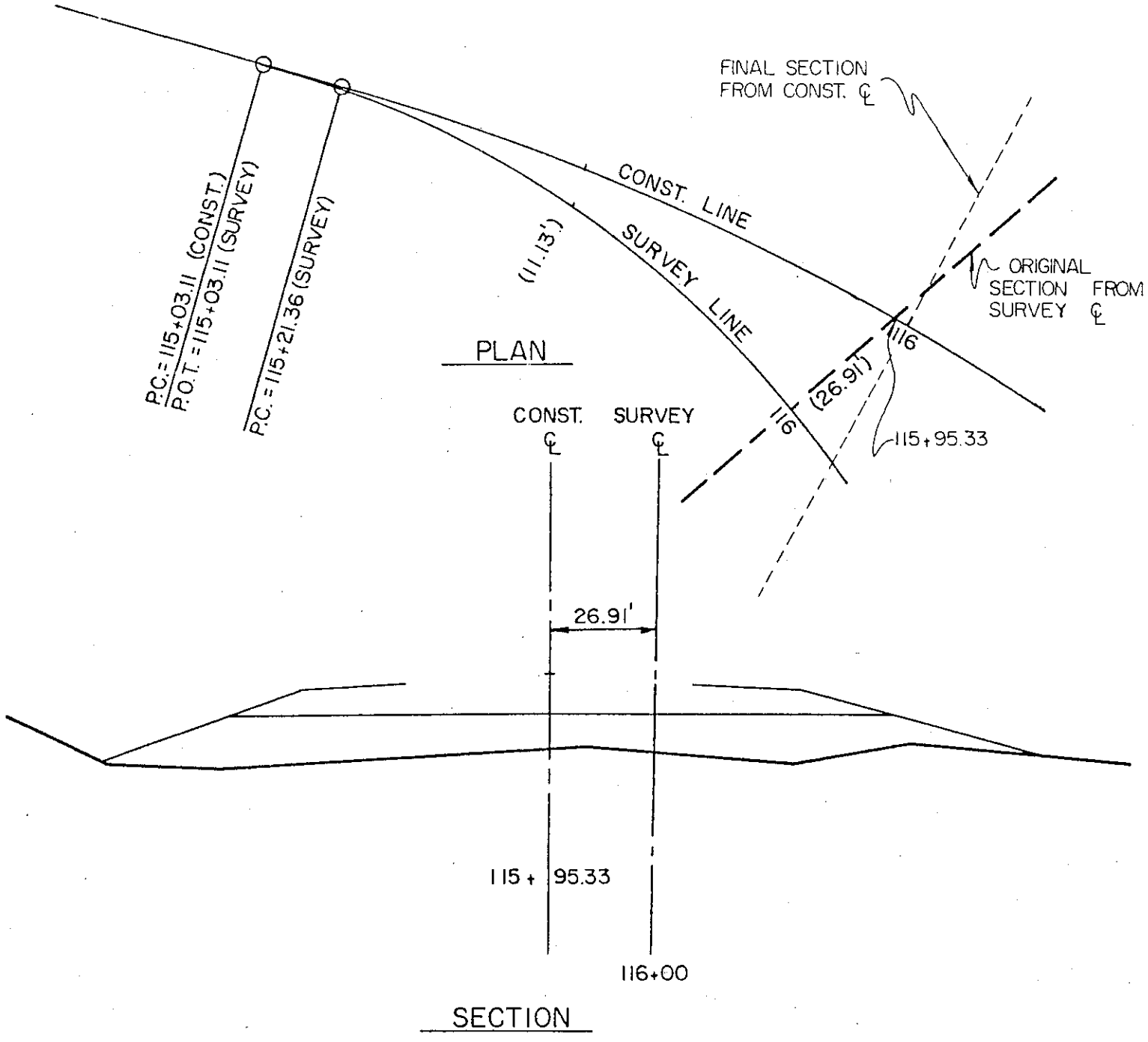
Final X-Sections Rte 13

		382.16				
39+00						EP 22 / 8.0; 39 / 9.7; 37 / 9.4; 22.5 / 9.4; 7.5; EP 22 / 7.9; 37 / 9.1; 52 / 9.5; SE 62 / 7.6
						Cont. pg. 9; Ditch SE 65 / 9.1 → Cont. pg. 9
39+16	DI Lt. 38'		13.3			Top Grate
	Approx. Bottom is 3.5' from grate.					
	Bottom covered with packed sand.					
TP#2	5.66	375.35	12.47	369.69		39+50 ℄
TP#3	7.88	376.68	6.55	368.80		40+75, Lt. 30' Stone
BM#39			15.68	361.00	360.97	Elev. Bk#6954, pg. 30

Continued in Bk. #7206, pg. 13

If continuing the bench run for finals use the adjusted elevation, i.e. 360.97, to determine the new H.I. as shown below.

BM #39	1.68	362.65			360.97
39+50					



SURVEY CONSTRUCTION LINE OFFSET

4/29/77
420.5

421 CHANNEL WORK

Final cross sections on channel changes shall be taken shortly after the completion of the channel work so that accurate quantities may be determined before any erosion takes place or before accretion.

Channel sections are taken in the same way as final roadway cross section, however only one old ground (O.G.) shot will be necessary.

Be sure to note stone fill where it occurs with the channel section.

Dunbarton P-3639-C

E Chase
R. Dubriske
E. Ford
D. Richards

9 June 1953
Sunny (80°+)

3

Final X-Sections Mud Brook Channel

BM#56	1.04	368.42			367.38
10+50					
11+00					
11+50					
	Inverted Rod Length =			16.51	
BM#56		(INV)	15.46		
			1.05	367.37	

Elev. this Bk. pg. 89

℄	EW	TOP BANK	EDGE BROOK		EB	TB	EW	℄
37	20	13	10		9	13	28	45
4.7	4.5	5.3	8.4	8.5	8.6	5.2	5.2	5.0

℄	EW	TB	EB		EB	TB		
35	16	12	9		10	13	28	40
4.8	5.0	5.1	8.6	8.7	8.5	5.1	5.3	5.4

EW	℄
50	59
5.1	5.0

℄	EW	TB	EB		EB	TB	EW	℄
45	28	14	11		11	13	17	35
4.7	5.0	5.2	8.5	8.8	8.6	5.1	5.2	4.9

3/15/77
421.2

FINAL SURVEYS

422 LEDGE SECTIONS

Final ledge sections will be taken wherever original sections were taken except where the final earth slope covers the ledge. The beginning and ending of the exposed ledge will be shown (zero ledge section).

The final ledge section will be taken in the same manner as a final roadway section except at odd stations only the exposed ledge will be taken with an Earth (E) shot at the beginning and end of the ledge section.

On ledge sections show Earth (E), Earth to Ledge (EL), Ledge (L), Ledge to Earth (LE) and Earth (E).

Dunbarton P-3639-C

Final Sections & Ledge

E. Chase
R. Dubriske
E. Ford
D. Richards

3 Sept 1953
Sunny (75°±) 3

		392.46									
			OG	EW		EP		EP			
70+00			56	49	30	22		22	30	34	38
			10.8	9.6	9.3	4.2	3.7	4.3	6.7	7.2	6.8
						OG				EW	OG
						75		51	63	68	79
						10.9		3.4	2.8	2.6	1.5
								OG			
								93			
								1.1			
70+13	Zero Ledge Section										
								E	EL	L	L
70+25								38	42	44	50
								6.9	6.4	2.1	2.0
								LE	E		
								55	60		
								1.9	1.3		

Usually the Party Chief will continue the ledge sections with the final roadway sections as shown.

423 PITS

Generally, pit finals will be taken from the same base line and along the same offset line as taken during originals. Odd sections should be taken in the final pit when necessary to more accurately describe the pit. This is especially true where an isolated earth mound is within the pit area. Odd final sections need only identify the change between the normal final pit section and need not cover the full length of the pit.

When the final pit configuration is going to be greatly different from the original layout the original pit extensions should be from a new base line and the pit broken down into two pits. The new base line should be handled in the same way as a property line in a pit area. Final pit sections will be taken at the same crossing point as the originals on all property line and new base lines. This should give better final pit coverage.

When the final elevations are taken on a pit of the same name as the original sections, place the finals in the same book. If the pit name has changed, place the final pit sections in another book with a reference to the original pit section.

Dunbarton P-3639-C

Final Pit Sections Town Pit #1

E. Chase
R. Dubriske
E. Ford
D. Richards

25 Aug 1953
Clear & Windy
(65°±)

3

BM#100	12.06	337.22			325.16	Elev. Bk# 7006, pg. 14						
	All sections will be to the right.											
	Pit Layout, this Bk, pg 8											
101+10			O.G. 275 / 7.6			Zero Pit						
101+25			OG 250 / 7.1	EP 269 / 6.8 · 275 / 12.2	300 / 13.0	325 / 13.0	338 / 12.8	345 / 7.2	EP 350 / 7.0	OG 375 / 6.8	OG 392 / 5.5	
101+50			O.G. 275 / 7.0	EP 279 / 6.9 · 285 / 12.7	300 / 13.0	325 / 12.8	350 / 12.5	365 / 19.1	Orig. Pit Limit 375 / 19.5	390 / 22.5	418 / 24.6	Cont pg. 9
TP#1	20.21	356.10	1.33	335.89		101+50, Rt. 300 stk.						
101+75			Cont. from pg. 7	306 / 18.6	319 / 20.3	333 / 21.1	352 / 20.9	390 / 20.1	460 / 20.4	510 / 20.3	523 / 16.2	538 / 13.1 · 552 / 7.6
			Orig. Pit Limit 575 / 2.1	Cont pg. 9								

3/15/77
423.2

Dunbarton P.3639-C E. Chase & Crew 25 Aug 1953

Final Pit Sections Town Pit #1

4

356.10

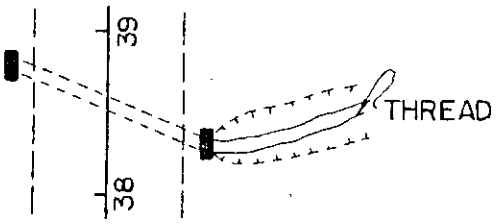
102	Cont. from pg. 8	300 16.2	325 20.1	380 20.6	470 20.7	493 20.9	506 18.3	533 14.2	559 9.1	581 3.3	600 1.1	Cont pg. 9		
102+11	+11			327 20.2	Mound 331 19.8	356 20.1								
102+19	+19 Earth Mound	N ← 305 20.1	311 20.2	319 14.3	330 12.1	339 11.9	348 15.6	→ N 358 20.3	368 20.2					
102+25	+25	Cont. from pg. 11	300 14.8	318 20.3	N 386 20.1	401 20.2	487 20.6	501 20.4	518 16.3	526 13.3	541 10.7	567 6.6		
		583 4.1	600 2.2	Cont pg. 11										

3/15/77
423.3

FINAL SURVEYS

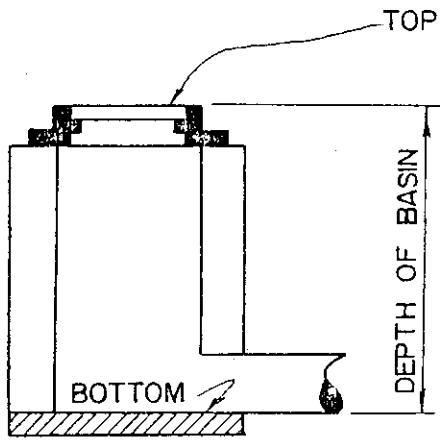
430 DRAINAGE

Locate catch basins, drop inlets, manholes and cross pipes by plus & offset and elevation, and profile outlet ditches.

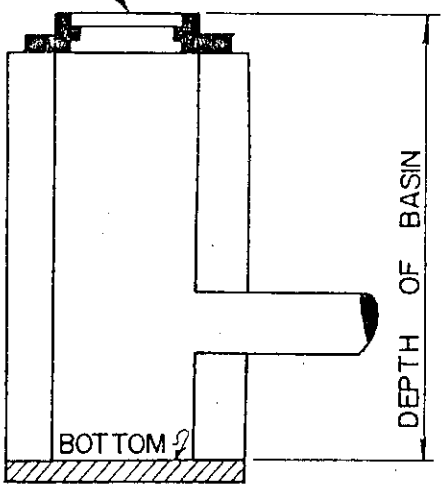


PIPE AND OUTLET DITCH

Other roadway ditches will be taken in the roadway section. Drainage structures should be included with the final roadway sections.



DROP INLET



CATCH BASIN

On catch basins (CB) and drop inlets (DI) locate the center of the grate or cover by plus & offset and elevation.

Measure the depth of basin from the top of the grate and describe the condition of the bottom of the basin when actual bottom cannot be given. Pipe invert elevations are not necessary and will not be taken.

See final cross sections for typical notes.

FINAL SURVEYS

440 BENCH MARKS

In the process of taking finals, all turning points will be taken to the nearest hundredth (0.01) of a foot. The Bench level run must go through each bench mark used and will not be taken as a side shot. Bench marks destroyed during construction will be noted in the field book.

The level run must check within four hundredths (0.04) of a foot between each bench mark used during construction. The level line will be adjusted at each bench mark.

For typical field notes see cross sections.

3/15/77

450 BOUNDS

All highway bounds will be located with transit and steel tape from a control point. The horizontal angle will be doubled and recorded with the horizontal distance or slope distance and vertical angle.

This requirement will be on all highway projects completed after January 1, 1974.

Dunbarton P-3639-C
Bound Layout

E. Chase
L. Dubriske
E. Ford
D. Richards

H. Harsey
R. Guilmette
L. Mitchell
M. Chase

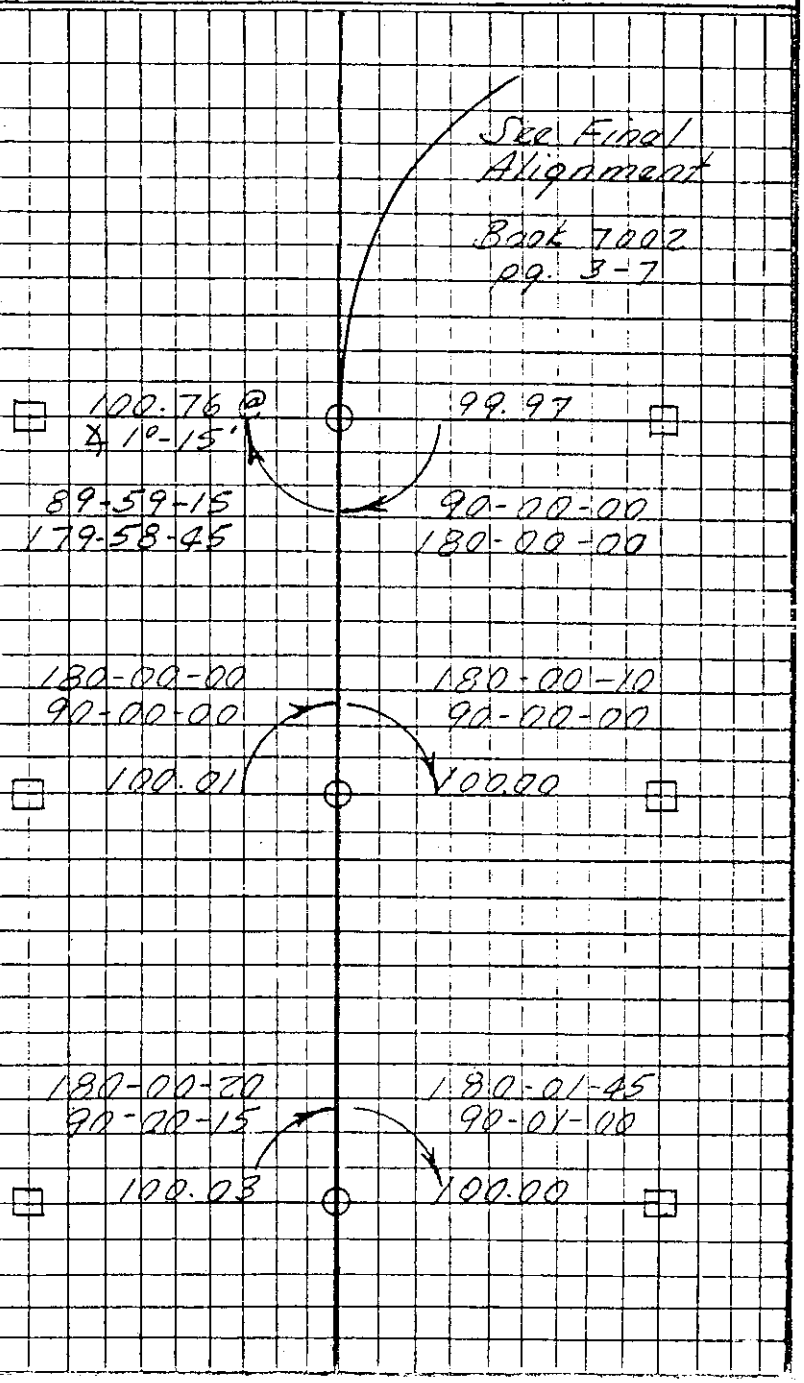
Final / Bound Location

9/16/53
Cloudy (65°±)

3

4/14/53
Clear (50°±).

Sta.	Offset Lt.	Offset Rt.	Replaced	Date
43+42.37	100.00	100.00	H. Harsey	5/9/53
38+00	100.00	100.00	In work area	E. Chase 5/1/53
34+00	100.00	100.00	In work area H. Harsey	E. Chase 5/1/53 5/9/53



4/29/77
450.2

FINAL SURVEYS

PLATES

SECTION V

INDEX

TYPICAL INDEX PAGE

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CONCORD P-1266 PAGE

INDEX CONTINUED

LOUDON P-6777

PORTSMOUTH- BERLIN
P-6789
Alignment No. Bd. Curve #69

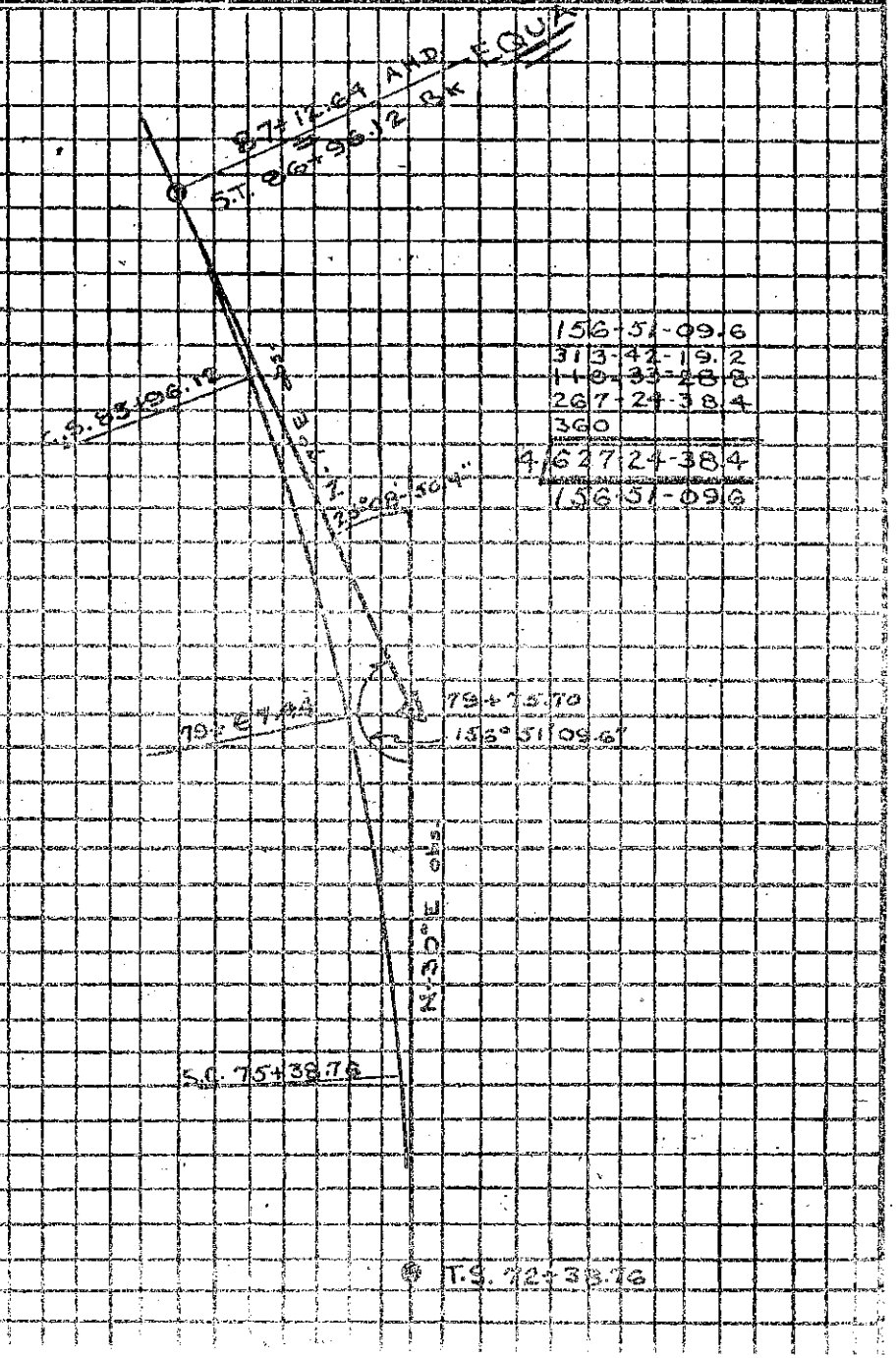
White C.P.
Brown ⊼
Green Ch.
Black 1

12-3-71

Snow Showers

3

Sta.		Defl.	Curve Data
EQUATION			P.I. = 79+75.70
87+12.64 AHEAD			Δ = 23°08'50.4" Lt.
86+96.12 BACK	S.T.	0°-00'	θ = 3°00'
+50		0° 01.2'	Δ_c = 17°08'50.4"
86+0		0° 05.8'	D_c = 2°00'
+50		0° 13.8'	T_s = 736.94'
85+0		0° 25.0'	L_c = 857.36'
+50		0° 39.6'	E_s = 60.78'
84+0		0° 57.5'	R_c = 2864.79'
	C.S.	1°-00.0'	L_s = 300.00'
83+96.12	C.S.	8°34'25"	L.T. = 200.03'
+50		8°06.7'	S.T. = 100.03'
83+0		7°36.7'	X_c = 299.92'
+50		7°06.7'	Y_c = 5.24'
82+0		6° 36.7'	T.S. = 72+38.76'
+50		6°06.7'	S.C. = 75+38.76'
81+0		5° 36.7'	Mid Pt. = 79+67.44'
+50		5°-06.7'	C.S. = 83+96.12'
80+0		4° 36.7'	S.T. = 86+96.12 Back
+67.44	MID PT.	4°-17.2'	= 87+12.64 Ahead
+50		4°-06.7'	EQUATION
79+0		3°-36.7'	
+50		3°-06.7'	
78+0		2°-36.7'	
+50		2°-06.7'	
77+0.		1°-36.7'	
+50		1°-06.7'	
76+0		0°-36.7'	
+50		0°-06.7'	
	S.C.	0°00'	
75+38.76	S.C.	1°-00'	
75+0		0°-46.2'	
+50		0°-30.3'	
74+0		0°-17.8'	
+50		0°-08.5'	
73+0		0°-02.6'	
+50		0°-00.1'	
72+38.76	T.S.	0°-00'	



CILLEYVILLE

S-6969

N.H. Rte. # 20 Relocation Curve # 2

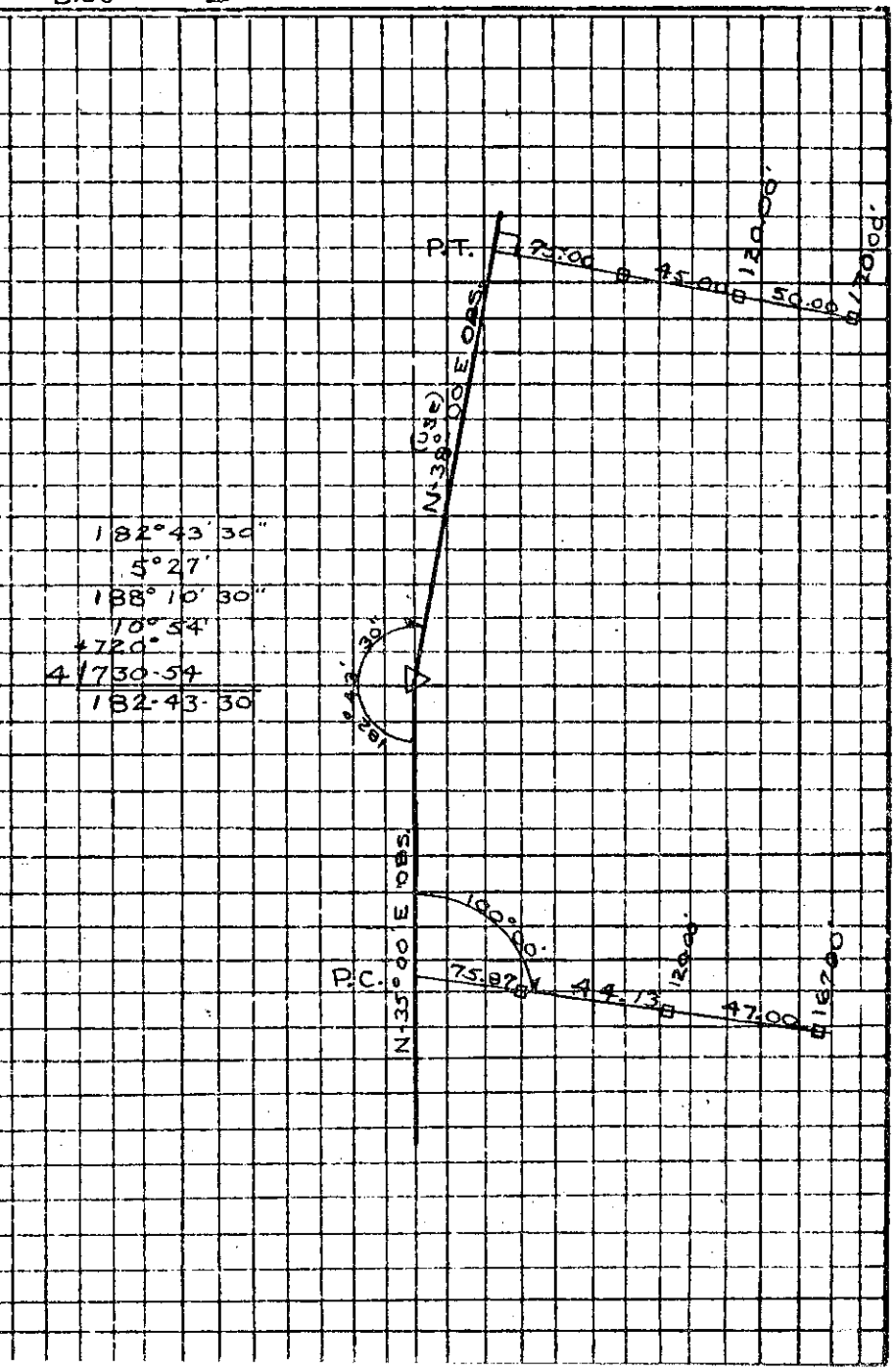
Black C.P.
White ℄
Green Ch.
Blue ⊥

5-12-..2

Fair 3

Sta.		Defl.	Curve Data
	Construction Line		P.I. 321+11.89
			Δ = 2°43' 30" Rt.
			D = 0° 45'
			R = 7639.44'
			T = 181.70'
			L = 363.33'
			E = 2.16'
			P.C. 319+30.19
			M.P. 321+11.86
			P.T. 322+93.52
93.52	P.T.	1°-21.75'	
322+			
+50		1°-12'	
322+0		1°-00.75'	
+50		0°-49.5'	
+11.86	M.P.	0°-40.5'	
321+0		0°38.25'	
+50		0° 27'	
320+0		0°-15.75'	
+50		0°-04.5'	
30.19	P.C.	0°-00'	
319+0			

182°43' 30"
5°27'
188° 10' 30"
10° 54'
720°
4 | 730-54
182-43-30



PORTSMOUTH

P-3875

ALIGNMENT

N.H. Rte. 16 Relocation Curve #3

Jones C.H.
Smith J.T.
Woods C.G.
Brown J.

2/28/72

Cloudy-Cold

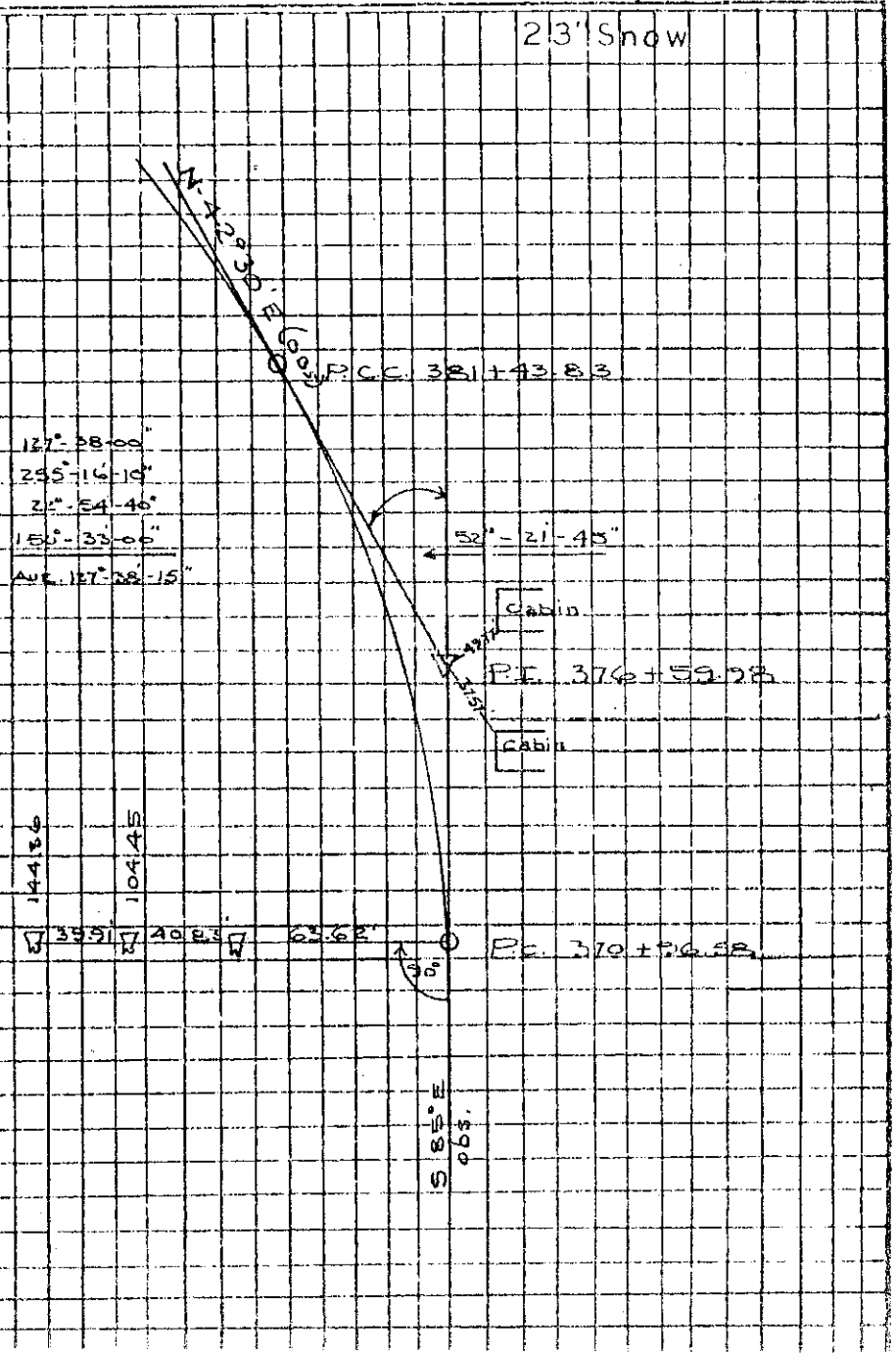
2.3" Snow

Compound Curve (Part A)

Sta.		Defl.
+43.83	P.C.C.	26°-10.87'
381		25°-05.1'
+50		23°-50.1'
380		22°-35.1'
+50		21°-20.1'
379		20°-05.1'
+50		18°-50.1'
378		17°-35.1'
+50		16°-20.1'
377		15°-05.1'
+50		13°-50.1'
+20.20	M.P.	13°-05.43'
376		12°-35.1'
+50		11°-20.1'
375		10°-05.1'
+50		8°-50.1'
374		7°-35.1'
+50		6°-20.1'
373		5°-05.1'
+50		3°-50.1'
372		2°-35.1'
+50		1°-20.1'
371		0°-05.1'
+96.58	P.C.	0°-00'
370		

Curve Data

P.I. = 376+59.98
Δ = 52°-21-45" LT.
D = 5°-00
R = 1145.92
T = 563.40
L = 1047.25
E = 131.01'
P.C. = 370+96.58
M.P. = 376+20.20
P.C.C. = 381+43.83



PORTSMOUTH

Jones C.P.
Smith ⊼
Woods Ch.
Brown ⊥

3-1-..

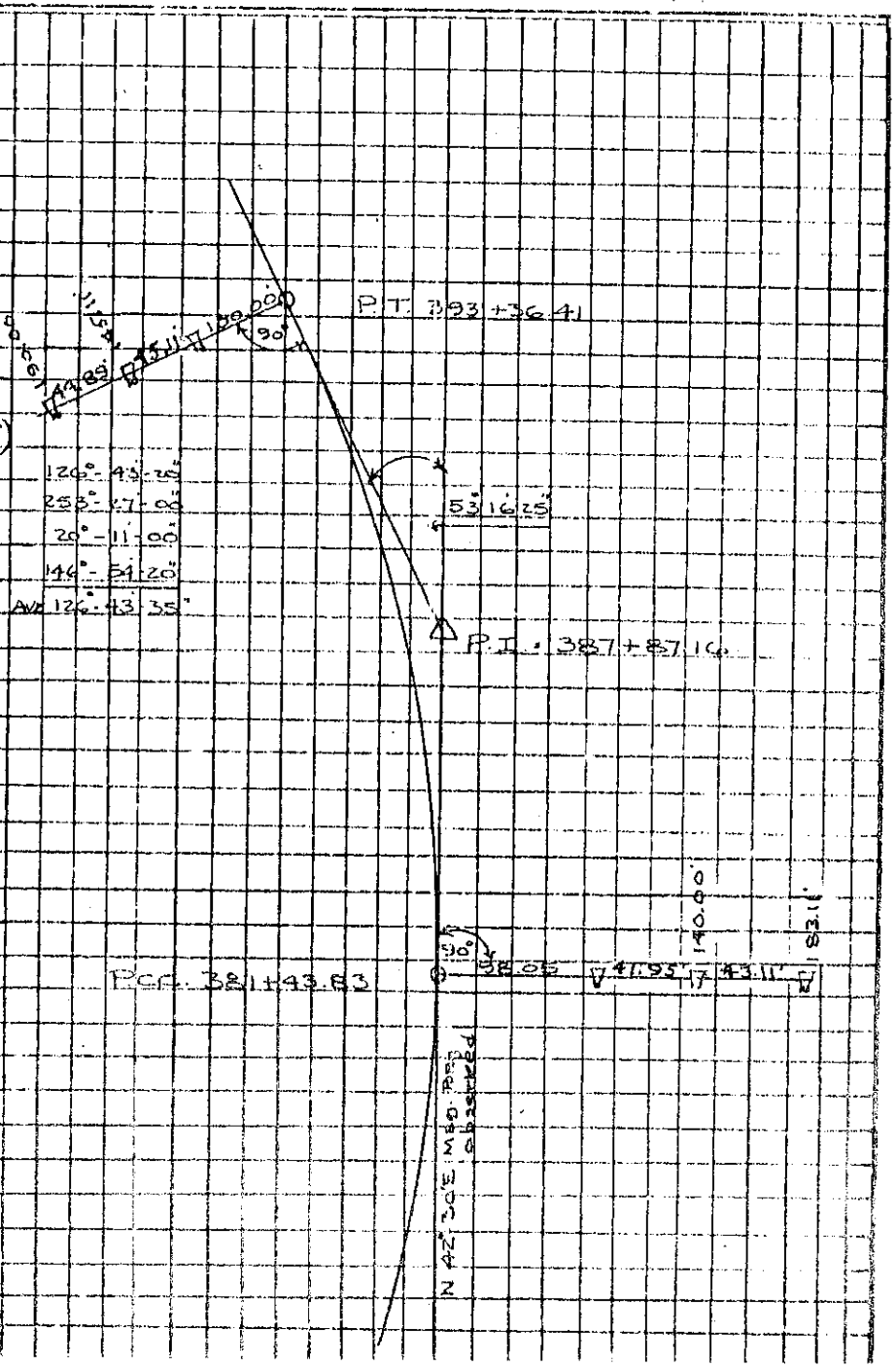
Alignment N.H.Rte.16 Relocation Curve # 3

Fair

4

Compound Curve Part 'B'

Sta.		Defl.		Data
+36.41	P.T.	26°-38.21'	P.T. =	387+87.16
392		25°-49.42'	Δ =	53°-16'-25" LT.
+50		24°-42.41'	D =	4.4671° (4°-28'-02")
392		23°-35.41'	R =	1282.74
+50		22°-28.40'	T =	643.33
391		21°-21.39'	L =	1192.58
+50		20°-14.39'	E =	152.30'
390		19°-07.38'	P.C.C. =	381+43.83
+50		18°-00.37'	M.P. =	387+40.12
389		16°-53.37'	P.T. =	393+36.41
+50		15°-46.36'		
388		14°-39.35'		
+50		13°-32.35'		
+40.12	M.P.	13°-19.11'		
387		12°-25.34'		
+50		11°-18.33'		
386		10°-11.33'		
+50		9°-04.32'		
385		7°-57.31'		
+50		6°-50.31'		
384		5°-43.30'		
+50		4°-36.29'		
383		3°-29.29'		
+50		2°-22.28'		
382		1°-15.27'		
+50		0°-08.27'		
+43.83	P.C.C.	0°-00		
381				



GOSHEN

P-2000

Route 10 Relocation Curve # 3 (Inaccessible)

Richards C.P.
Jewett ⊼
Bean Ch.
Nute ⊥

7-7-

Fair 3

Sta.		Defl.
+50.79	P.T.	29°-23.9'
+50		25°-20.1'
65		25°-20.1'
+50		21°-20.1'
64		17°-20.1'
+67.05	M.P.	14°-42.0'
+50		13°-20.1'
63		9°-20.1'
+50		5°-20.1'
62		1°-20.1'
+83.31	P.C.	0°-00
61		

Curve Data

P.I. =	63+85.08
Δ =	58-47-50 LT.
D =	16°-00
R =	358.10
T =	201.77
L =	367.48
E =	201.76
P.C. =	61+83.31
M.P. =	63+67.05
P.T. =	65+50.79

C = Log 265.43 / Log Sin 58°47'50" x Log Sin 29°38'50"

C = 2.423950 / 9.932183 x 9.694305

C = 2.423950 + 9.694305 = 12.118255 − 9.932183

C = 2.186072

c = 153.49

29°38'50" + 29°09'00" = 58°47'50"

"A"
150°-51'-00"
30°-11'-30"
9°-33'-00"
243°-24'-00"
AVE 150°-51'-00"

"C"
136°-21'-30"
30°-42'-30"
9°-03'-30"
24°-24'-40"
AVE. 150°-31'-10"

a = 2.423950 + 9.684616 = 12.108566 − 9.932138 = 2.176428

a = 151.16

P.T. 65+50.79
P.C. 61+83.31
29°-09'-00"
29°-38'-50"
58°-47'-50"
153.49'
265.43'
367.48'
201.76'
201.77'
A
B
C
D
a

MILLVILLE
P-1234

Green C.P.
White ⊼
Black Ch.
Brown 1

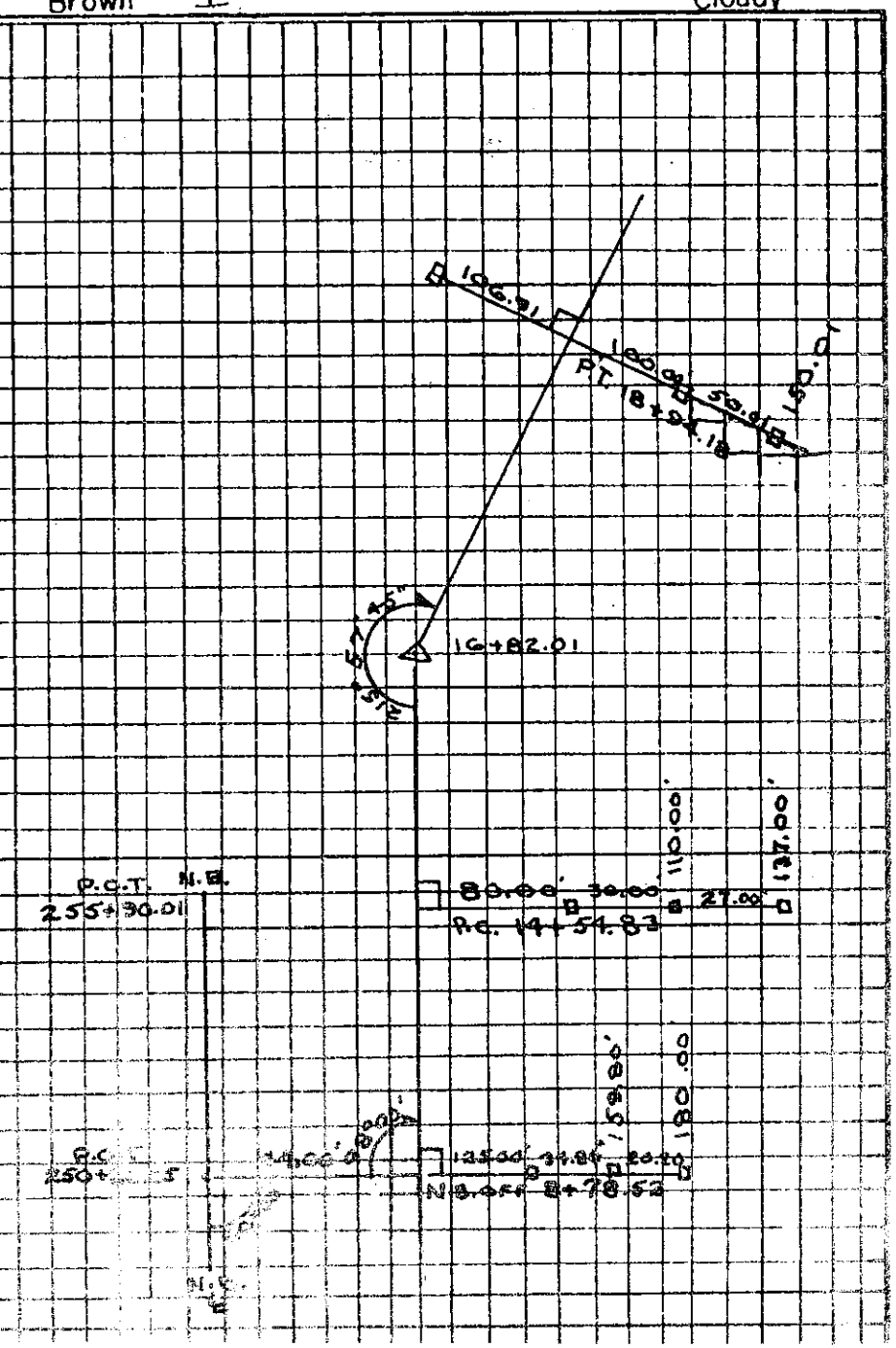
5-6-72

Cloudy

3

Alignment – N.B. Off Ramp Curve 2

Sta.		Defl.	Curve Data	
			P.I.	16+82.01
			Δ	35°57'45" Rt.
			D	8° 11' 06.4"
			R	700'
			T	227.18'
			L	439.35'
			E	35.90
			P.C.	14+54.83
			M.P.	16+74.51
			P.T.	18+94.18
			dist.	defl.
			1'	2.4555'
18+94.18	P.T.	17-58.9	25'	1°01'39"
+75		17-11.8		
+50		16-10.4	arc.	chord
+25		15-09.0	25.00'	25.00'
18+0		14-07.6	50.00'	49.99'
+75		13-06.2		
+50		12-04.8		
+25		11-03.4		
17+0		10-02.0		
+75		9-00.7		
+50		7-59.3		
+25		6-57.9		
16+0		5-56.5		
+75		4-55.1		
+50		3-53.7		
+25		2-52.3		
15+0		1-50.9		
+75		0-49.5		
14+54.83	P.C.	0°00'		



MILLVILLE
P-1234

Green C.P.
White ℄
Black Ch.
Brown ⊥.

5-7-72

Fair 4

Alignment - N.B. Off Ramp Curve 3

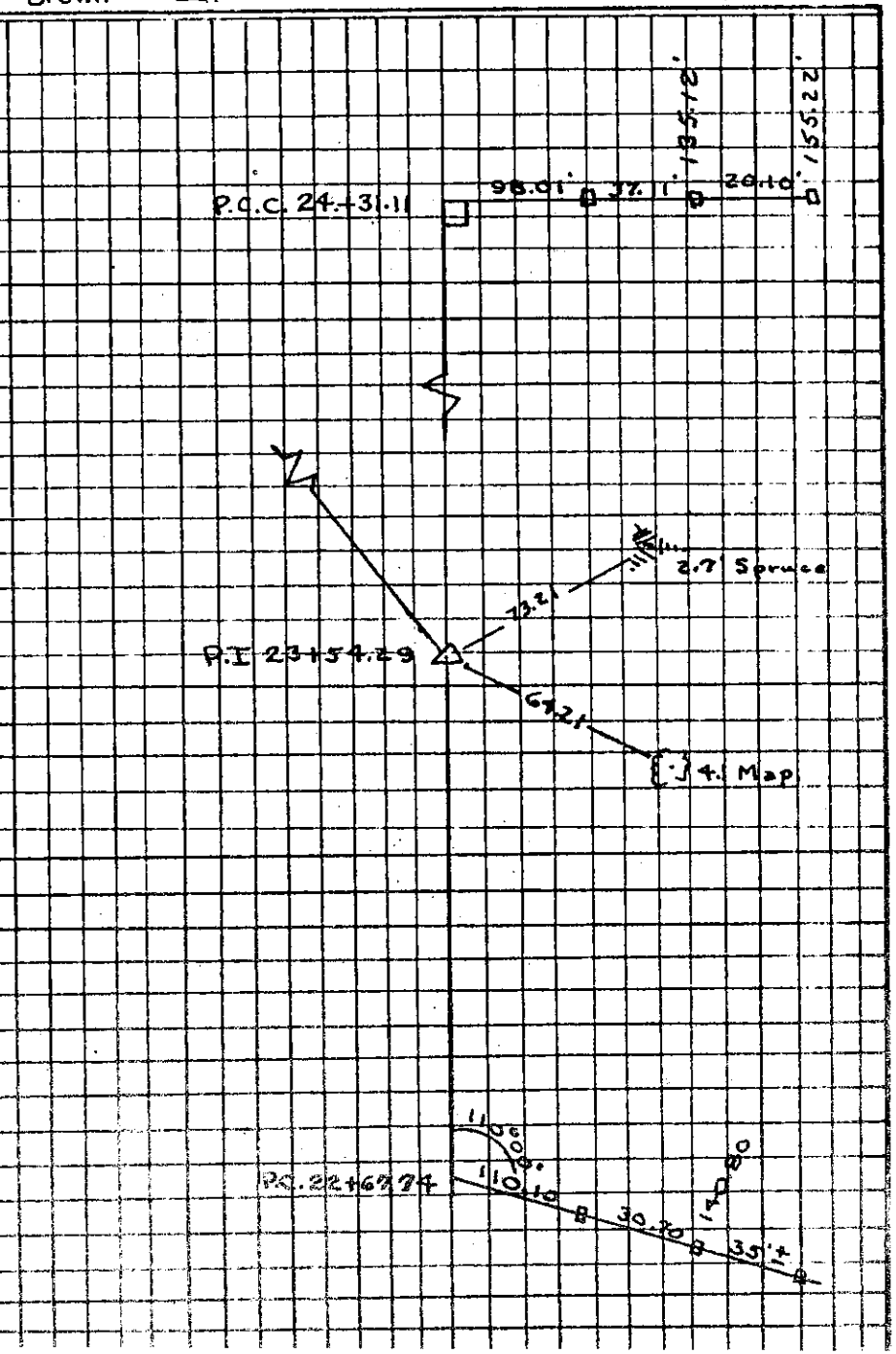
Sta.		Defl.
24+31.11	P.C.C.	23°24.1'
+25		22° 31.6'
24+0		18° 56.7'
+75		15° 21.8'
+50		11° 47.0'
+49.42	M.P.	11° 42.0'
+25		8° 12.1'
23+0		4° 37.3'
+75		1° 02.4'
22+67.74	P.C.	0°00'

Curve Data

P.I.	23+54.29
Δ	46°48'10" Lt.
D	28° 38' 52.4"
R	200.00'
T	86.55'
L	163.37'
E	17.93
P.C.	22+67.74
M.P.	23+49.42
P.C.C.	24+31.11

dist.	defl.
1.00'	8.594'
25.00'	3°34.86'

Arc	Chord
25.00'	24.98'
50.00'	49.87'



MILLVILLE

P-1234

Green C.P.
White ℄
Black Ch.
Brown ⊥

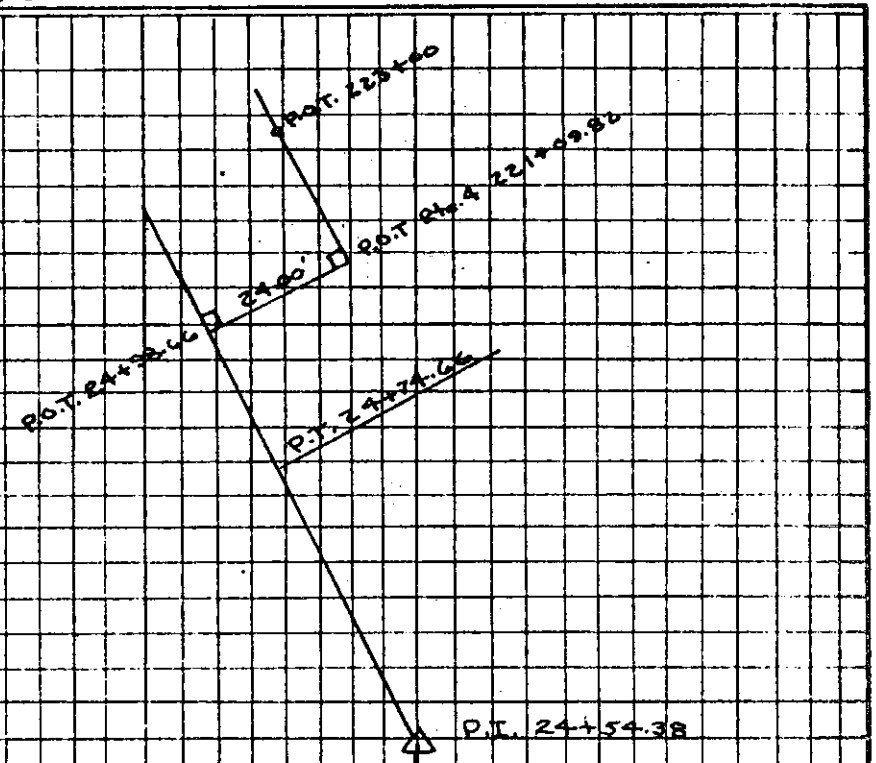
5-7-7

Alignment - N.B. Off Ramp Curve 4 Fair 5

Sta.		Defl.	Curve Data
			P.I. 24+54.38
			Δ 49°54' 33.6" Lt.
			D 114°35' 29.6"
			R 50.00'
			T 23.27'
			L 43.55'
			E 5.15'
			P.C.C. 24+31.11
			P.T. 24+74.66

Dist.	Defl.
1.00'	34.377'
25.00'	14°19.94'

Arc	Chord
25.00'	24.74'



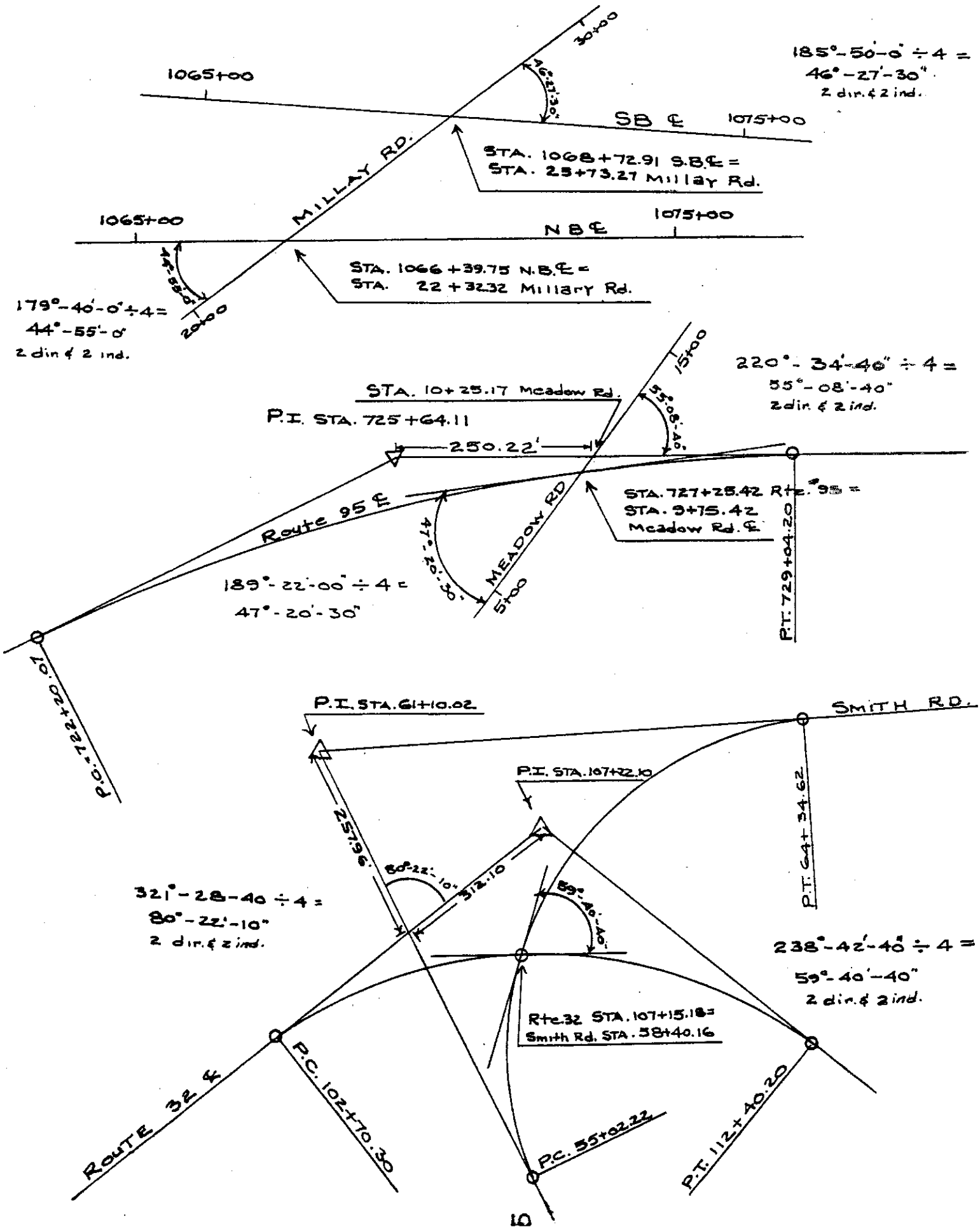
This curve not run in field this date.

24+74.66	P.T.	24°57'16.8"
+75		24°21.3'
+50		10°01.4'
24+31.11	P.C.C.	0°00'

P.C.C. 24+31.11
this page 4

6

METHODS OF INTERSECTING LINES



Reference - Route Surveys
Transition Curves for
Highway

Highway Spiral Curves.

1. Based on Cubic Spiral as Developed by the Public Roads Administration

2. Based on Arc Definition

Notation and Symbols

P.I. - Point of Intersection of Main Tangents

T.S. - Tangent Spiral, Common Point of tangent and spiral of near transition

S.C. - Spiral Curve, common point of spiral and circular curve of near transition.

Computations and Field Location for Spiral Curve

Ls, Length of Spiral is based on the Degree of curve (Dc), the Design Speed and the Desirable slope of Pavement edges.

Rc - Radius in feet of Main Circular Curve (Dc) selected for Use.

V - Design Speed in M.P.H.

1.6- Friction Factor based on Slope of Pavement (Banks)

$$Ls = 1.6 \frac{V^3}{R}$$

Table 12 (Route Surveys)

Select Length of Spiral Curve in nearest multiple of 50'. Cubic Spiral is defined as curve whose degree of curve increases directly with the distance from the Point of Spiral (T.S. in Fig.) Then:-

(1) $$\frac{D}{Dc} = \frac{L}{Ls}$$

(2) $$D = \frac{DcL}{Ls}$$

The Spiral Angle at the S.C. is

(3) $$\theta_s = \frac{LsDc}{200}$$

Circular Curve

Find Δc For Circular Curve

$$\Delta c = \Delta - 2\theta s$$

$$\Delta c = \Delta - \frac{LsDc}{100}$$ Substitute (3) above.

Find Length (Lc) for Circular Curve.

$Lc = 100 \frac{\Delta c}{Dc}$ Compute other functions of circular curve in normal manner.

Spiral Curve

$\theta_s = \frac{LsDc}{200}$ See (3) above

Find Total Tangent (Ts)

$Ts = (Rc + p) \tan \frac{\Delta}{2} + k$ Table 17A (Route Surveys) for Values of p & k

Now Find Station Locations (Control Points)

T.S. = P.I. - Ts

S.C. = T.S. + Ls Also = P.C. Circular Curve

C.S. = S.C. + Lc " = P.T. Circular Curve

S.T. = C.S. + Ls

Now Locate Control Points in Field by Spiral Tangents.

L.T., Long Tangent Table 13 - Use θ (determined previously)

(P.I.)s = T.S. + L.T. (Intersection of Short & Long Tangents)

1. Turn θs and measure out S.T. or Short Tangents to establish S.C. and P.C. of Circular Curve.
2. Measure out Circular Curve Tangent Distance to P.I. of Circular Curve.
3. Set Control Points on Far Spiral in same manner.

Now compute Spiral Deflections ∅ for even stations and run in on ground from T.S.

$$\phi = \frac{\theta}{3} = \left\{\frac{L}{Ls}\right\}^2 \frac{\theta s}{3}$$

$$\phi = 1/3 \left[\frac{\theta s}{(Ls)^2}\right] L^2$$

(Apply minus correction when values of ∅ exceed 7° as below

$$\phi = \frac{\theta}{3} - C$$

$$C = \frac{\theta^3}{20,000}$$

or See Table 23.

METHOD OF COMPUTING SPIRAL DATA FROM "TRANSITION CURVES FOR HIGHWAYS" BY JOSEPH BARNETT, PUBLIC ROADS ADMINISTRATION

Given:

P.I. = 162 + 90.8
Δ = 35° - 25' - 30" Rt.
D_c = 5° - 00'
Design Speed = 40 M.P.H.

Length of Spiral = L_s

Direct from Table I using Degree of Curve and Design Speed

L_s = 150'

Tangent Distance P.I. to T.S. = T_s

External Distance P.I. to Center of Curve = E_s

By interpolation from Table IV using Degree of Curve, Length of Spiral and Delta

T_s for D_c = 5° and L_s 150'
T_s Δ = 35° = 436.55
T_s Δ = 36° = 447.59
T_s Δ = 35° - 25' - 30" = 441.2
E_s Δ = 35° = 56.5
E_s Δ = 36° = 59.8
E_s Δ = 35° - 25' - 30" = 57.9

Delta for Curcular Curve = Δ_c Page 17

$$\Delta_c = \Delta - \frac{L_s D_c}{100} \quad \text{or} \quad \Delta_c = \Delta - 2\theta_s$$

$$\Delta_c = 35^\circ\text{-}25'\text{-}30" - \frac{150 \times 5^\circ}{100} \qquad \Delta_c = 35^\circ\text{-}25'\text{-}30" - 2 \times 3^\circ - 45'$$

$$\Delta_c = 35^\circ\text{-}25'\text{-}30" - 7^\circ - 30' \qquad \Delta_c = 35^\circ\text{-}25'\text{-}30" - 7^\circ - 30'$$

$$\Delta_c = 27^\circ\text{-}55'\text{-}30" \qquad \Delta_c = 27^\circ\text{-}55'\text{-}30"$$

Length of Circular Curve = L_c Page 17

$$L_c = \frac{\Delta_c \times 100}{D_c}$$

$$L_c = \frac{27^\circ - 55' - 30" \times 100}{5^\circ}$$

$$L_c = 558.5$$

Arc Lengthening for Offset from Center Line of Spirals

Computations for 30.00' offset to left from center line

New Spiral Length L_s'

$$L_s' = L_s + \left(\text{Offset} \frac{\theta_s}{\text{Radian}}\right)$$

$$L_s' = 150 + \left(30 \frac{3.75^\circ}{57.3^\circ}\right)$$

$$L_s' = 150 + 1.96$$

$$L_s' = 151.96$$

New Arc Lengths L'

$$L' = L + \left(\text{Offset} \times 3 \times \frac{\theta}{\text{Radian}}\right)$$

Arc T.S. 158 + 49.6 to 158 + 50

$$L' = 0.4 + \left(30 \times 3 \times \frac{0^\circ}{57.3^\circ}\right)$$

$$L' = 0.4 + 0$$

$$L' = 0.4$$

T.S. 158 + 49.6 to 159

$$L' = 50.4 + \left(30 \times 3 \times \frac{0.142^\circ}{57.3^\circ}\right)$$

$$L' = 50.4 + 0.22$$

$$L' = 50.62$$

Arc 158 + 50 to 159 = 50.62 - 0.4 = 50.22

T.S. to 159 + 50

$$L' = 100.4 + \left(30 \times 3 \times \frac{0.564^\circ}{57.3^\circ}\right)$$

$$L' = 100.4 + 0.89$$

$$L' = 101.29$$

Arc 159 to 159 + 50 = 101.29 - 50.62 = 50.67

Arc 159 + 50 to S.C. 159 + 99.6 = 151.96 - 101.29 = 50.67

Station	L = Distance from T.S.	L^2	Deflection Angle $L^2 \times 0.000056$
T.S. = 158 + 49.6	0	0	0° - 00'
+ 50	0.4	0	0° - 00.0'
159	50.4	2540	$0.142^\circ = 0^\circ$ - 08.4'
+ 50	100.4	10080	$0.564^\circ = 0^\circ$ - 33.3'
S.C. = 159 + 99.6	150.0	22500	$1.260^\circ = 1^\circ$ - 15.0'
			$\frac{\theta_s}{3} = \frac{3^\circ - 45'}{3} = 1^\circ - 15'$

Spiral Deflection Angles from an Intermediate Setup

Degree of Curvature at Point of Setup is Computed by Simple Proportion:

$$D = \frac{L_1}{L_s} \times D_c$$

$$D = \frac{50.4}{150} \times 5^\circ \quad \text{for Station 159 + 00}$$

$$D = 1.68^\circ$$

Circular curve deflection angles for this curvature are computed and to them are added or subtracted to the spiral deflection angles from the T.S. for the same distance to obtain deflection angles at the intermediate setup.

Station	L_1 Distance from 159 + 00	L_1^2	ϕ for Spiral $L_1^2 \times 0.000056$	ϕ for Circular Curve $\frac{L_1}{200} \times 1.68^\circ$	Deflection Angle ϕ
T.S. = 158 + 49.6	50.4	2540	0.142°	0.423°	$0.281^\circ = 0^\circ - 16.9'$
159 + 00	0	0	0	0	$0^\circ - 00'$
+ 50	50	2500	0.140°	0.420°	$0.560^\circ = 0^\circ - 33.6'$
S.C. = 159 + 99.6	99.6	9920	0.556°	0.837°	$1.393^\circ = 1^\circ - 23.6'$

Spiral Deflection Angles from the C.S. to S.T.

Deflection angles for a setup on the S.C. computed the same as for an Intermediate setup.

$D = D_c$ in this case

$D = 5^\circ$ for C.S. 165 + 58.1

Station	L_1 Distance from C.S.	L_1^2	ϕ for Spiral $L_1^2 \times 0.000056$	ϕ for Circular Curve $\frac{L_1}{200} \times 5^\circ$	Deflection Angle ϕ
C.S. = 165 + 58.1	0	0	0	0	$0^\circ - 00'$
166	41.9	1756	0.098°	1.047°	$0.949^\circ = 0^\circ - 57.0'$
+ 50	91.9	8446	0.473°	2.297°	$1.824^\circ = 1^\circ - 50.3'$
167	141.9	20136	1.127°	3.547°	$2.420^\circ = 2^\circ - 25.8'$
S.T. = 167 + 08.1	150.0	22500	1.260°	3.750°	$2.490^\circ = 2^\circ - 30'$

FUNCTIONS OF TRANSITIONS

Ls 150' TABLE V

Dc	θs	P	K	Xc	Yc	L.T.	S.T.	L.C.	Dc
0°-30'	0.375	0.08	75.00	150.00	0.33	100.00	50.00	150.00	0°-30'
0°-45'	0.5625	0.12	75.00	150.00	0.49	100.00	50.00	150.00	0°-45'
1°-00'	0.75	0.16	75.00	150.00	0.65	100.00	50.00	150.00	1°-00'
1°-15'	0.9375	0.21	75.00	150.00	0.82	100.00	50.00	150.00	1°-15'
1°-30'	1.125	0.25	75.00	149.99	0.98	100.00	50.00	150.00	1°-30'

Ls 200' TABLE V

Dc	θs	P	K	Xc	Yc	L.T.	S.T.	L.C.	Dc
0°-30'	0.50	0.15	100.00	200.00	0.58	133.33	66.67	200.00	0°-30'
0°-45'	0.75	0.22	100.00	200.00	0.87	133.34	66.67	200.00	0°-45'
1°-00'	1.00	0.29	100.00	199.99	1.16	133.34	66.67	200.00	1°-00'
1°-15'	1.25	0.37	100.00	199.99	1.45	133.34	66.67	200.00	1°-15'
1°-30'	1.50	0.44	100.00	199.99	1.75	133.34	66.67	199.99	1°-30'

Ls 250 TABLE V

Dc	θs	P	K	Xc	Yc	L.T.	S.T.	L.C.	Dc
0°-30'	0.625	0.25	125.00	250.00	0.91	166.67	83.34	250.00	0°-30'
0°-45'	0.9375	0.34	125.00	249.99	1.36	166.67	83.34	250.00	0°-45'
1°-00'	1.250	0.46	125.00	249.99	1.82	166.67	83.34	250.00	1°-00'
1°-15'	1.5625	0.57	125.00	249.98	2.27	166.67	83.34	249.99	1°-15'
1°-30'	1.875	0.68	124.99	249.97	2.73	166.66	83.34	249.99	1°-30'

computed by Buchanan
checked by Peterson

FUNCTIONS OF TRANSITIONS

$L_s = 300$

D_c	θ_c	p	K	X_c	Y_c	LT	ST	LC	D_c
0°30'	0.75	0.33	150.00	299.99	1.31	200.00	100.00	300.00	0°30'
0°45'	1.125	0.49	150.00	299.99	1.96	200.00	100.00	299.99	0°45'
1°-00'	1.50	0.66	150.00	299.98	2.62	200.01	100.01	299.99	1°-00
1°-15'	1.875	0.82	149.99	299.97	3.27	200.01	100.01	299.99	1°-15'
1°-30'	2.25	0.98	149.99	299.95	3.93	200.02	100.01	299.98	1°-30'

$L_s = 350$

D_c	θ_c	p	K	X_c	Y_c	LT	ST	LC	D_c
0°30'	0.875	0.45	175.00	349.99	1.78	233.34	116.67	350.00	0°30'
0°45'	1.3125	0.67	175.00	349.98	2.67	233.34	116.67	349.99	0°-45'
1°-00'	1.75	0.89	174.99	349.97	3.56	233.35	116.68	349.99	1°-00'
1°-15'	2.1875	1.12	174.99	349.95	4.45	233.35	116.68	349.98	1°-15'
1°-30'	2.625	1.33	174.99	349.93	5.34	233.36	116.69	349.97	1°-30'

$L_s = 400$

D_c	θ_c	p	K	X_c	Y_c	LT	ST	LC	D_c
0°30'	1.00	0.58	200.00	399.99	2.33	266.67	133.34	400.00	0°30'
0°45'	1.50	0.88	200.00	399.97	3.49	266.68	133.34	399.99	0°45'
1°-00'	2.00	1.16	199.99	399.95	4.65	266.68	133.35	399.98	1°-00'
1°-15'	2.50	1.45	199.99	399.92	5.82	266.69	133.36	399.97	1°-15'
1°-30'	3.00	1.74	199.98	399.89	6.98	266.71	133.37	399.95	1°-30'

Computed by Buchanan
Checked by Peterson

VALUES FOR DESIGN ELEMENTS RELATED TO DESIGN SPEED AND HORIZONTAL CURVATURE

D	R	V=30 mph			V=40 mph			V=50 mph			V=60 mph			V=65 mph			V=70 mph			V=75 mph			V=80 mph		
		e	L-Feet		e	L-Feet		e	L-Feet		e	L-Feet		e	L-Feet		e	L-Feet		e	L-Feet		e	L-Feet	
			2-lane	4-lane		2-lane	4-lane		2-lane	4-lane		2-lane	4-lane		2-lane	4-lane		2-lane	4-lane		2-lane	4-lane		2-lane	4-lane
0° 15′	22918′	NC	0	0	NC	0	0	NC	0	0	NC	0	0	NC	0	0	NC	0	0	NC	0	0	RC	240	240
0° 30′	11459′	NC	0	0	NC	0	0	NC	0	0	RC	175	175	RC	190	190	RC	200	200	.022	220	220	.024	240	240
0° 45′	7639′	NC	0	0	NC	0	0	RC	150	150	.022	175	175	.025	190	190	.029	200	200	.032	220	220	.036	240	240
1° 00′	5730′	NC	0	0	RC	125	125	.021	150	150	.029	175	175	.033	190	190	.038	200	200	.043	220	220	.047	240	240
1° 30′	3820′	RC	100	100	.021	125	125	.030	150	150	.040	175	175	.046	190	200	.053	200	240	.060	220	290	.065	240	320
2° 00′	2865′	RC	100	100	.027	125	125	.038	150	150	.051	175	210	.057	190	250	.065	200	290	.072	230	340	.076	250	380
2° 30′	2292′	.021	100	100	.033	125	125	.046	150	170	.060	175	240	.066	190	290	.073	220	330	.078	250	370	.080	260	400
3° 00′	1910′	.025	100	100	.038	125	125	.053	150	190	.067	180	270	.073	210	320	.078	230	350	.080	250	380	.080	260	400
3° 30′	1637′	.028	100	100	.043	125	140	.058	150	210	.073	200	300	.077	220	330	.080	240	360	.080	250	380	D max=2.5°		
4° 00′	1432′	.032	100	100	.047	125	150	.063	150	230	.077	210	310	.079	230	340	.080	240	360	D max=3.0°					
5° 00′	1146′	.038	100	100	.055	125	170	.071	170	260	.080	220	320	.080	230	350	D max=3.5°								
6° 00′	955′	.043	100	120	.061	130	190	.077	180	280	.080	220	320	D max=4.5°											
7° 00′	819′	.048	100	130	.067	140	210	.079	190	280	D max=5.0°														
8° 00′	716′	.052	100	140	.071	150	220	.080	190	290															
9° 00′	637′	.056	100	150	.075	160	240	D max=7.5°																	
10° 00′	573′	.059	110	160	.077	160	240																		
11° 00′	521′	.063	110	170	.079	170	250																		
12° 00′	477′	.066	120	180	.080	170	250																		
13° 00′	441′	.068	120	180	.080	170	250																		
14° 00′	409′	.070	130	190	D max=12.5°																				
16° 00′	358′	.074	130	200																					
18° 00′	318′	.077	140	210																					
20° 00′	286′	.079	140	210																					
22° 00′	260′	.080	140	220																					
		.080	140	220																					
		D max=23.0°																							

$e_{max}=0.08$

D—Degree of curve
R—Radius of curve
V—Assumed design speed
e—Rate of superelevation
L—Minimum length of runoff of spiral curve
NC—Normal crown section
RC—Remove adverse crown, superelevate at normal crown slope
Spirals desirable but not as essential above heavy line.
Lengths rounded in multiples of 25 or 50 feet permit simpler calculations.

OCT 20 1966

WEST EASTON
P-1000
Back Traverse Rte. II

Black C.P.
White T
Green C.C.
Brown L

2-

Flurries
Snow Depth 2

T @ STATION	B.S.	F.S.	DISTANCE	ANGLE	OBS. BEARING	
					S-52°W	
62+14.90	45+70.15	74+10.70	1195.80	188°-00'		187°-59-30
						15°-59-30
						204°-00-00
					S-44°W	32°-00-00
						AVE. 188°-00-00
45+70.15	38+88.10	62+14.90	1644.75	160°-05'		160°-04-30
						320°-10-00
						125°-15-00
					S-64°W	280°-20-00
						AVE. 160°-05'-00"
38+88.10	30+12.15	45+70.15	682.05	92°-00'		91°-59-30
						183°-59-30
						274°-00-00
					N-28°W	8°-00-00
						AVE. 92°-00-00°
30+12.15	21+90.18	38+88.10	875.95	183°-30'		183°-29-30
						6°-59-30
						190°-30-00
					N-31-W	11°-00-00
						AVE. 188°-30-00
21+90.18	10+00.00	30+12.15	821.97	194°-10'		194°-10-00
						28°-30'-30
						222°-30'-00
					N-45-15W	56°-40-00
						AVE. 194°-10-00
10+00.00	0+00	21+90.18	1190.18	172°-15'		172°-14-30
						349°-29-30
						156°-45-00
						329°-00-00 AVE. 172°-14'-30
					N 37°W	TRAV. STA. 0+00 = STA. 82+19.00

94+10.70 = 25+54.20
P.T. OF T.L.B. PROJECTS

62+14.90 = STA 37+50 OF T.L.B. PROTECT BUILT IN 1953

45+70.15

38+88.10

30+12.15

21+90.18

10+00.00

PROGRESS PROFILE

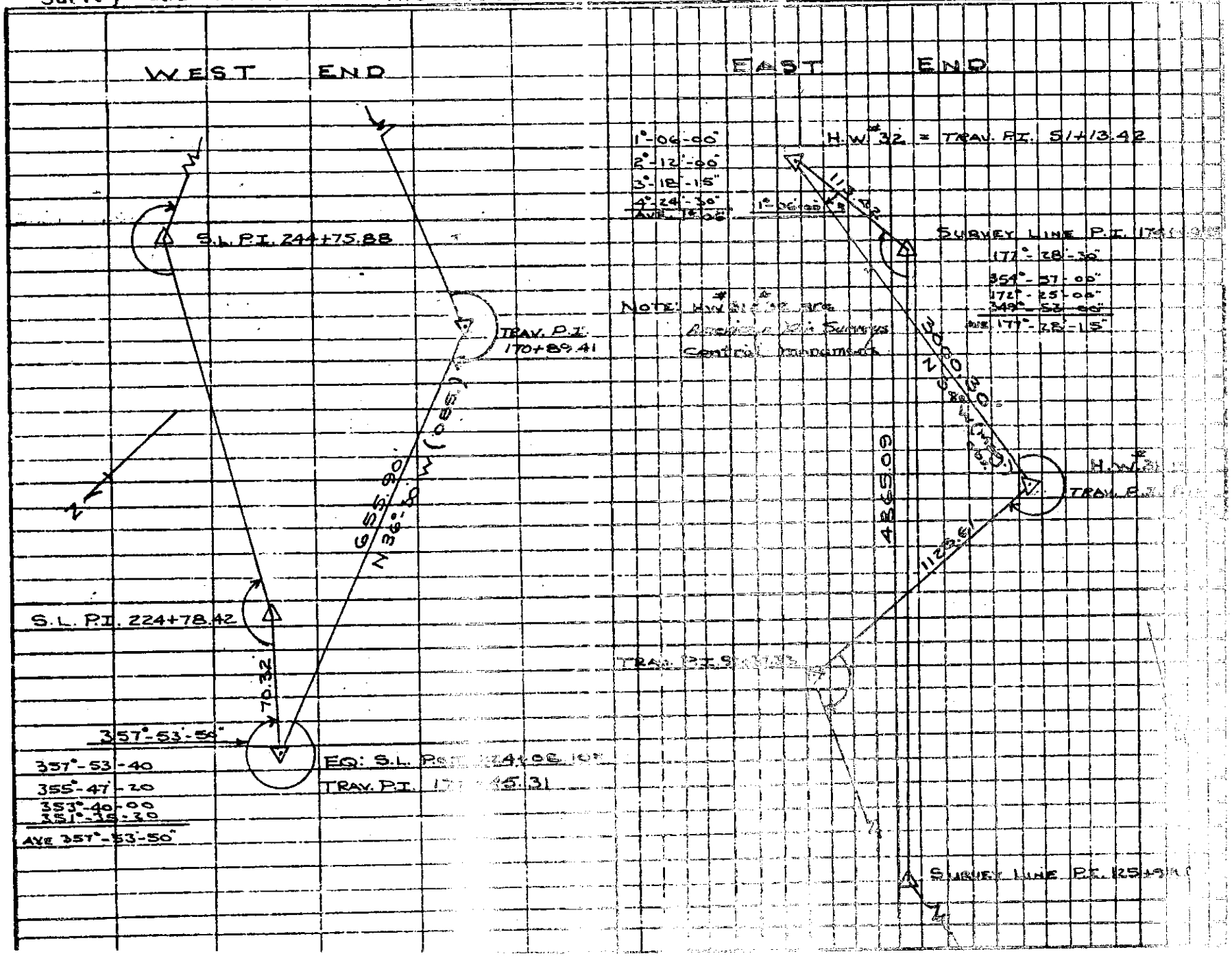
ORFORD – PIERMONT

P-1725

9/24/71

Survey and Traverse Line Closure

Clear – Warm



DEC. 6

JONES
SMITH
DAVIS
BROWN

PLYMOUTH P-7191

BENCH LINE

CLEAR & COLD

Sta	B.S.	H.I.	F.S.	Elev.	Adj. Elev.
BM D#35	1.48	577.50		576.02	
T.P. "A"			2.20	575.30	
NOTE:	All high and low turn intervals				
	should be at least one foot				
	vertically.				
BM D#35	2.48	578.50		576.02	
T.P. "A"	3.20	578.50		575.30	
T.P.#1H	0.92	578.40	1.02	577.48	
T.P.#1L	1.91	578.40	2.01	576.49	
T.P.#2H	4.00	581.40	1.00	577.40	
T.P.#2L	5.00	581.39	2.01	576.39	
T.P.#3H	1.20	574.20	8.40	573.00	
T.P.#3L	2.38	574.18	9.59	571.80	
BM #9	1.00	565.00	10.20	564.00	563.99
T.P. "B"	2.28	564.98	11.48	562.70	
T.P.#4H	1.25	558.00	8.25	556.75	
T.P.#4L	2.30	557.97	9.31	555.67	
T.P.#5H	5.25	558.75	4.50	553.50	
T.P.#5L	6.48	558.71	5.74	552.23	
T.P.#6H	8.50	563.50	3.75	555.00	
T.P.#6L	9.66	563.46	4.91	553.80	
BM #19	2.50	564.00	2.00	561.50	561.49
T.P. "C"	3.96	563.96	3.46	560.00	

About 11 miles north along U.S. Highway 3 from the post office at Plymouth, thence about 1.5 miles west of entrance to Plymouth Fairgrounds in the top of the southwest end of a large granite outcrop, 88' west of the center line of the highway and 3 feet above the level of the road. A disk, established by C. & G.S. D-35 1955 = ELEV. 576.022

NOTE: SHOW ADJUSTMENT IN GREEN: IF NO ADJ. SHOW CORRECT ELEV. IN GREEN-BOX ADJ.

VERT. SPIKE & WASHERS IN ROOT OF 4.5" Silver Birch STA. 9+14 62' LT.

VERT. SPIKE & WASHERS IN ROOT OF 6.0" C.M. P.L. STA. 10+01 75' RT.

PLYMOUTH P-7191

Jones C.P.
Smith ⊼
Davis ⊥
Brown Ck.

12-3[illegible]-7[illegible]

4

Foir 12" snow

BENCH LINE

	B.S.	H.I.	F.S.	Elev.	Adj. Elev.
T.P. 7H	4.00	563.80	4.20	559.80	
T.P. 7L	5.21	563.77	5.40	558.56	

NOTE: BENCH MARK #19 IS END OF LINE. CHECK BY EXTRA SETUP AS SHOWN ABOVE.

CEDARVILLE
P-1234

Green C.P.
Brown "
Black Ch.
White 1

5-12-72

3

Rte. # 100 Relocation Detail

Fair

POLE AND TREE LOCATION

Sta.	offset		Misc.	
10+17	Rt. 20'	Pole	N.E.T. & T. 117	P.S.Co. 5
10+23	Lt. 17'	4.7' Cir.	Maple	
10+76	Lt. 17'	5.0 "	"	
11+40	Rt. 23'	Pole	N.E.T. & T. 118	P.S.Co. 4
11+70	Lt. 14'	4.6' Cir.	Maple	

℄

Alignment Book 3210 Page 19-20

14+0
+50
+40
+32
+25
13+0
+75
+70
+63
+50
12+0
+50
+25
+17
11+0
+50
10+0

Field

1'x3'x2' M.B.M. Mons.

12" R.C.P.

Field

Edge of Timber

Top of Bank

See St. Pg. 37

103

6" W.

Avg.

OLDTOWNE
P-0101

Jones C.P.
Smith ℸ
White Ch.
Brown ⊥

2-3-

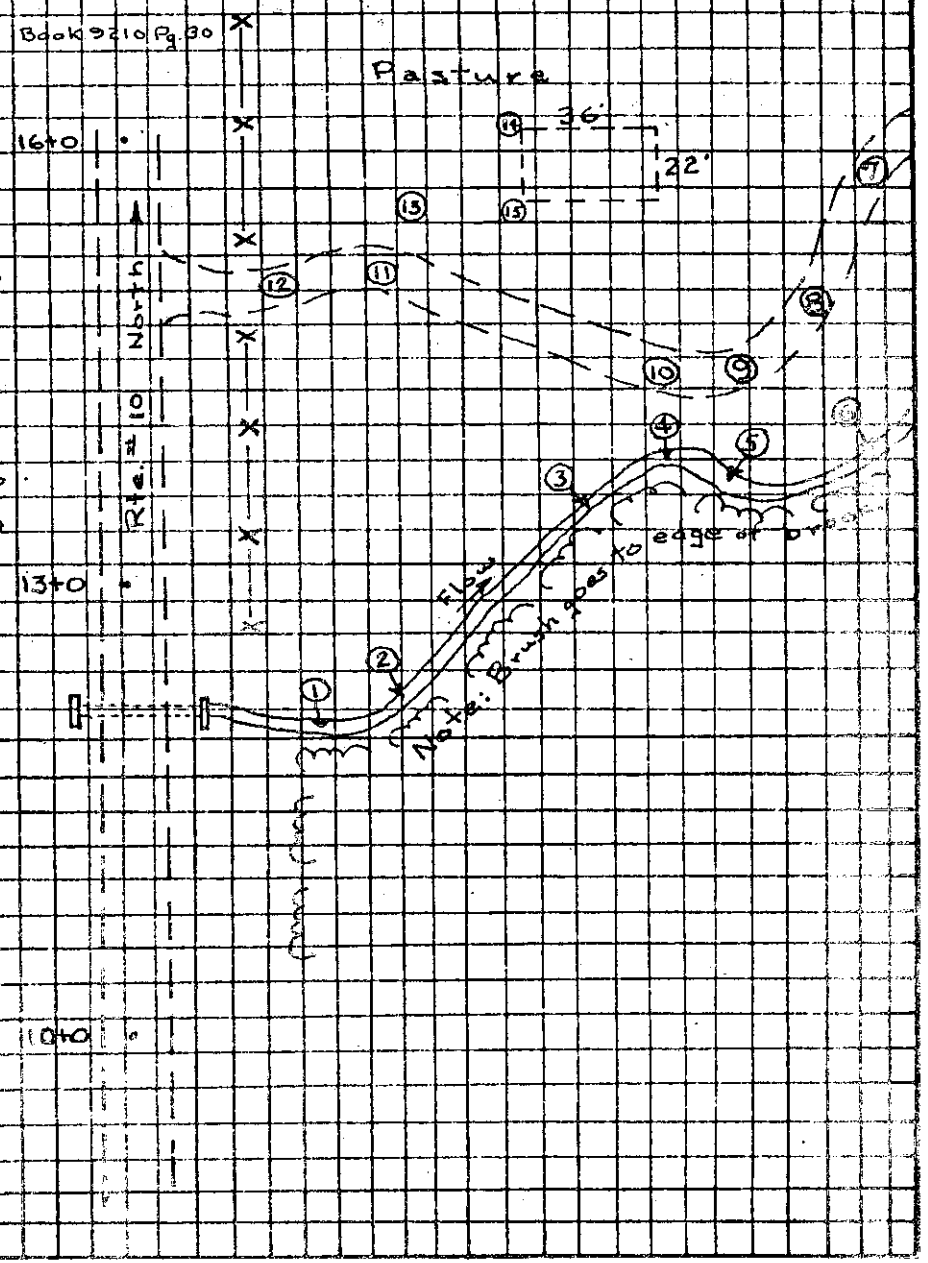
Flurries
30" Snow on ground

3

Stadia Detail

Shot *	Horiz. Angle	Distance	Vert. ∡	Rod Read.	Description	
ℸ on	P.O.T. 13+0	SIGHT	0°00	DIRECT ON	16+00	
ℸ 4.5'	ABOVE GROUND	VERTICAL ∡	TAKEN ON	4.5		
B.M. 100'	7.60	119.61				112.01
* 1	150°05'	71'	—	6.1	& 5' Wide Brook	
2	130°10'	104'	—	6.8	" "	"
3	91°10'	151'	—	7.3	" "	"
4	87°55'	173'	—	7.7	" "	"
5	92°00'	203'	—	8.0	" "	"
6	93°10'	241'	—	8.5	" "	"
7	62°15'	283'	+4°0'	4.5	& 8' Wood Road	
8	76°20'	250'	+6°10'	4.5	" "	"
9	81°30'	229'			" "	"
10	80°10'	201'			" "	"
11	46°20'	170'			" "	"
12	22°10'	162'			" "	"
13	43°00'	184'			& 4' Diam. Well - 17' Deep	4' Water
14	43°35'	207'			Abandoned Gran. Cellar	
15	46°30'	190'			"	"
ℸ	CHECK 0°00' ON	16+00				
B.M. 100			7.60		112.01	Above

For add'l detail see pgs. 10-17 this book.



CONCORD
P-1234

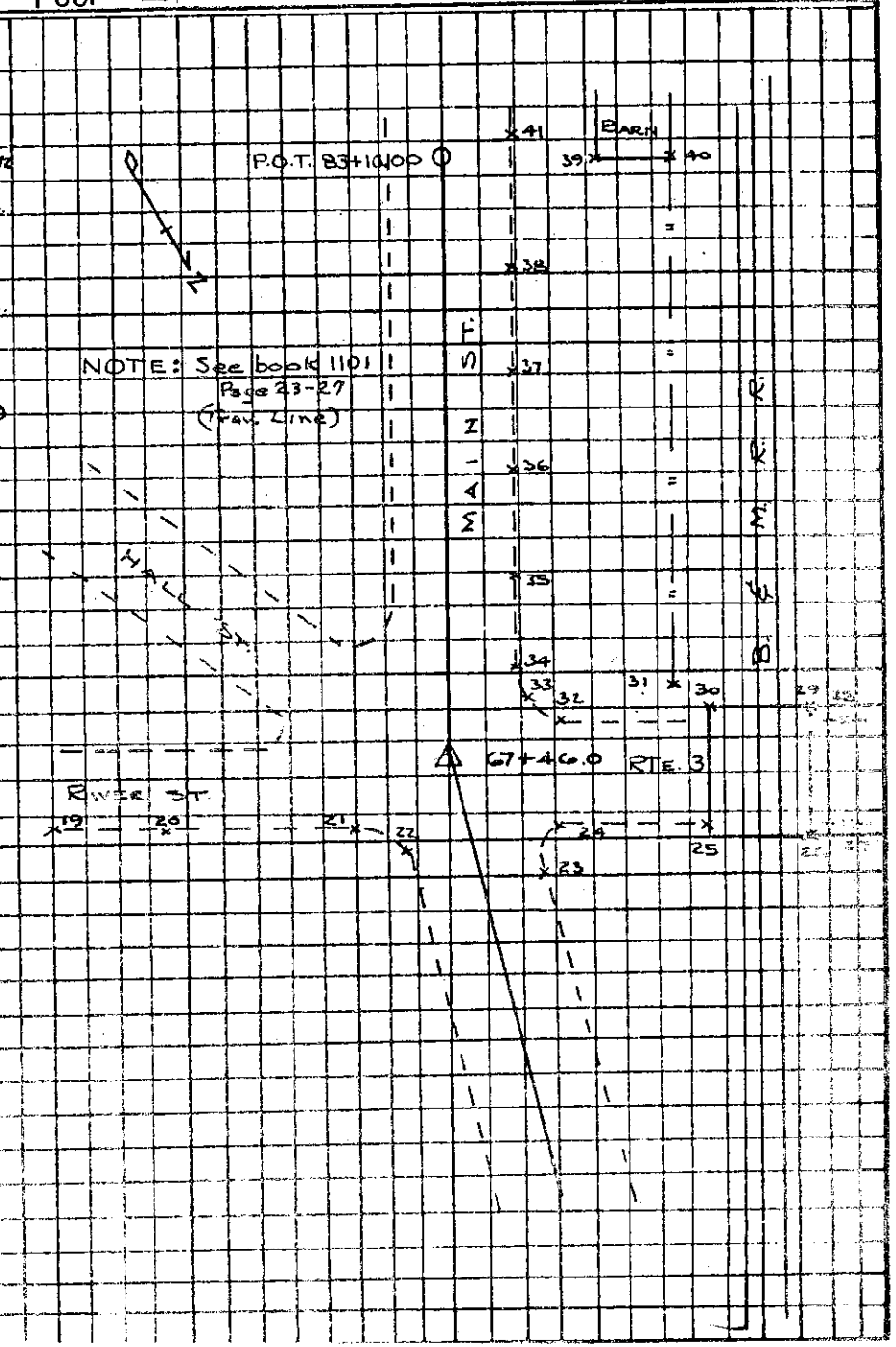
Mann C.P.
Hill X
Rich Ch.
Poor 1

5-. 3

Fair

Detail~Intersection of Main & Hall Sts.

SHOT NUMBER	HORIZ. ANGLE	DISTANCE	VERTICAL ANGLE	DIFF ELEV.	ELEV.	REMARKS
X on	P.I. 67+46.00		SIGHT 0°-00	DIR. ON	66+50.10	
H.I. =	4.8	(All vert & rod reading = 4.8)				N10°-12E
BM#66	6.21	207.81	0°-00'		201.60	SEE N.B. 7542 PAGE 13
19	65°-50'	334'	+2°-49'			T.W. Rt. #3
20	63°-05'	195'	+2°-41'			" "
21	58°-05'	58'	+1°-59'			" "
22	30°-30'	42'	LEVEL	6.1	201.7	" Main St.
23	339°-20'	49'	"	7.0	200.8	" " "
24	306°-45'	56'	"	9.0	198.8	T.W. Rte. #3
25	292°-06'	107'	-0°-50"			Cor. X-ing
26	281°-55'	168'	-1°-02'			" "
27	276°-45'	225'	-1°-39'			T.W. Rte. #3
28	271°-25'	220'	-1°-23'			" "
29	271°-50'	175'	-1°-10'			Cor. X-ing
30	272°-45'	169'	-1°-16'			" "
31	271°-40'	95'	-2°-13'			End Fn.
32	270°-20'	43'	-1°-39'			T.W. Rte. #3
ETC.						



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BEANTOWNE
S-0069

Davis C.P.
Brown ⊼
Jones Ch.
Smith ⊥

5-5-

Fair 3

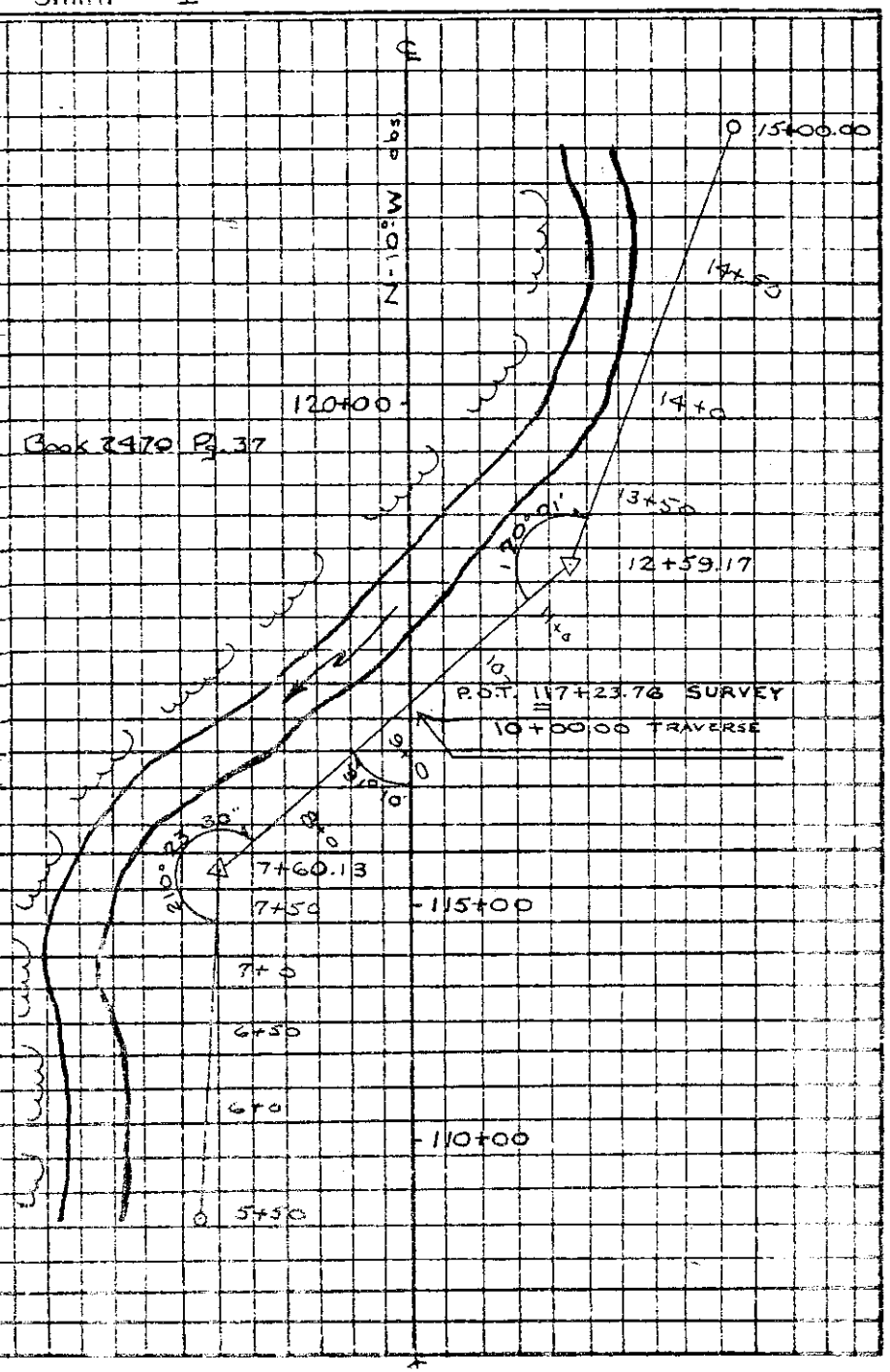
Traverse for Bubbly Brook detail and elevations

NOTE; Topography will be taken from the traverse by plus & offset or stadia.

TYPICAL PLUS & OFFSET

BM #111	7.92	119.99		112.07
Sta.	Off.	Rod Read.	Elev.	Remarks
6+0	Lt. 27	5.7		T.B
6+0	Lt. 32	7.4		℄ Brk.
6+0	Lt. 37	5.9		T.B
6+0	Lt. 45	—		B.L.
6+50	Lt. 30	5.6		T.B.
6+50	Lt 34	7.2		℄ Brk.
6+50	Lt. 39	5.7		T.B.
6+50	Lt. 47	—		B.L.
ETC.				

See Plate # 27 for typical stadia procedure.



anchester – Hooksett P-1[illegible]50

Route 3 x–ing of I-93

Brown C.P.
White X
Black Ch.
Green ⊥

Feb. 15, 1972

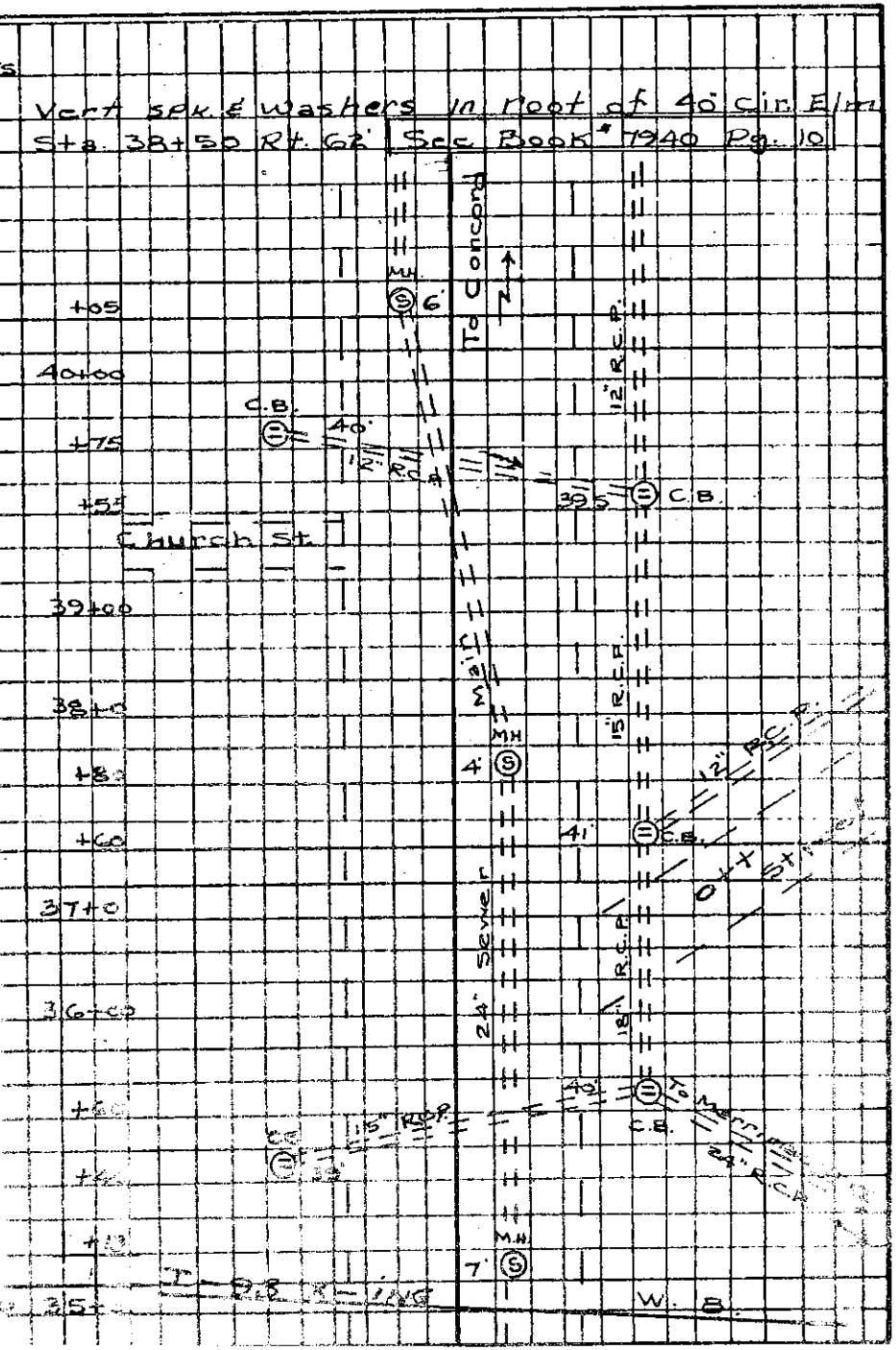
Fair – Cool

3

Storm and Sanitary Sewer Detail

Station	B.S.	H.I.	F.S.	Elev.	Remarks
B.M.#38	2.50	270.90		268.40	
35+13	M.H.	Top Rim	4.3	266.6	
		Flow	14.0	256.9	
+40	C.B. Lt.	Top Rim	4.3	2666	
		Invert	7.3	263.6	
		Sump	10.3	260.6	
+60	C.B. Rt.	Top Rim	4.2	266.7	
Inlet	15" R.C.P.		7.9	263.0	
	18" R.C.P.		8.2	262.7	
Outlet	24" R.C.P.		7.0	263.9	
		Sump	10.4	260.5	
37+60	C.B. Rt.	Top Rim	4.0	266.9	
Inlet	15" R.C.P.		8.1	262.8	
outlet	18" R.C.P.		9.0	261.9	
Inlet	12" R.C.P.		8.1	262.8	
		Sump	10.8	260.1	
+80	M.H. Rt.	Top Rim	3.8	267.1	
		Flow	7.0	263.9	
39+55	C.B. Rt.	Top Rim	3.6	267.3	
Inlet	12" R.C.P.		7.8	263.1	
"	12" R.C.P.		6.9	264.0	
		Sump	9.2	261.7	
+75	C.B. Lt.	Top Rim	3.2	266.[illegible]	
outlet	12" R.C.P.		6.3	263.[illegible]	
		Sump	9.0	260.[illegible]	
40+05	M.H. Lt.	Top Rim	2.8	26[illegible]	
		Flow	5.7	260.[illegible]	
B.M.#38			2.51	26[illegible]	268.40

Vert spk. & washers in root of 40" Elm
Sta. 38+50 Rt. 62' | Sec. Book 7240 Pg. 10



30

LACONIA

P-1776

B & M Railroad Crossing at sta. 12 + 15.00

Thomas C.P.
Richard ⊼
Harris Ch.
Bean 1

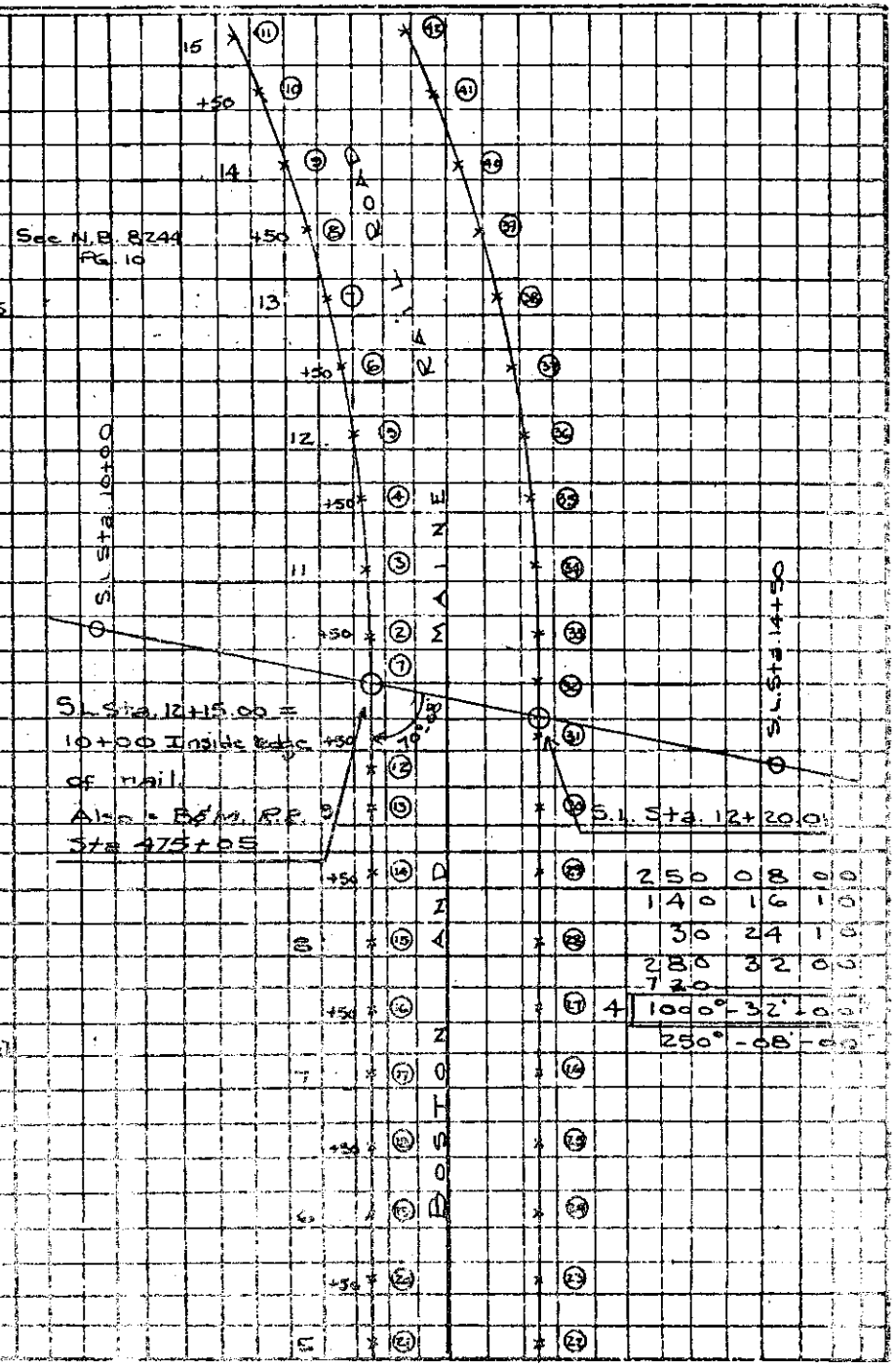
Clear

3

⊼ on Survey Sta. 12+15.00
F.S. 0°-00' on Survey Sta. 10+00
All ∠s measured to the right

BM#12 8.32 680.45 672.13 See N.B. 8244 Pg. 10

Shot no.	Taped DIST.	Hor. ∠	Rod	Elev.	Remarks
1	——	——	4.12	676.33	10+00
2	50'	70°-05'-00"	4.23	76.22	+50
3	100'	70°-03'-20"	4.34	76.11	11
4	150'	69°-40'-00"	4.45	76.00	+50
5	200'	68°-50'-20"	4.57	75.88	12
6	250'	67°-37'-40"	4.67	75.78	+50
7	300'	66°-29'-20"	4.89	75.56	13
8	350'	65°-21'-00"	5.00	75.45	+50
9	400'	64°-12'-40"	5.12	75.33	14
10	450'	63°-04'-20"	5.26	75.19	+50
11	500'	61°-56'-00"	5.39	75.06	15
12	50'	250°-08'-00"	4.05	76.40	9+50
13	100'	" " "	3.89	76.56	9
14	150'	" " "	3.72	76.73	+50
15	200'	" " "	3.59	76.86	8
16	250'	" " "	3.47	76.98	+50
17	300'	" " "	3.37	77.08	7
18	350'	" " "	3.32	77.13	+50
19	400'	" " "	3.25	77.20	6
20	450'	" " "	3.18	77.27	+50
21	500'	" " "	3.11	77.34	5+00
22	Radial to	Shot no. 21	3.10	77.35	outside rail
23	" "	" " 20	3.18	77.27	" "
24	" "	" " 19	3.26	77.19	" "
25	" "	" " 18	3.31	77.14	" "
26	" "	" " 17	3.37	77.08	" "
27	" "	" " 16	3.40	77.05	" "
28	" "	" " 15	3.43	77.02	" "
29	" "	" " 14	3.56	76.89	" "
30	" "	" " 13	3.74	76.71	" "
31	" "	" " 12	3.85	76.60	" "



31

BOW

P-0123

Ben C.P
Crook ⊼
Strong Ch.
Weak ⊥

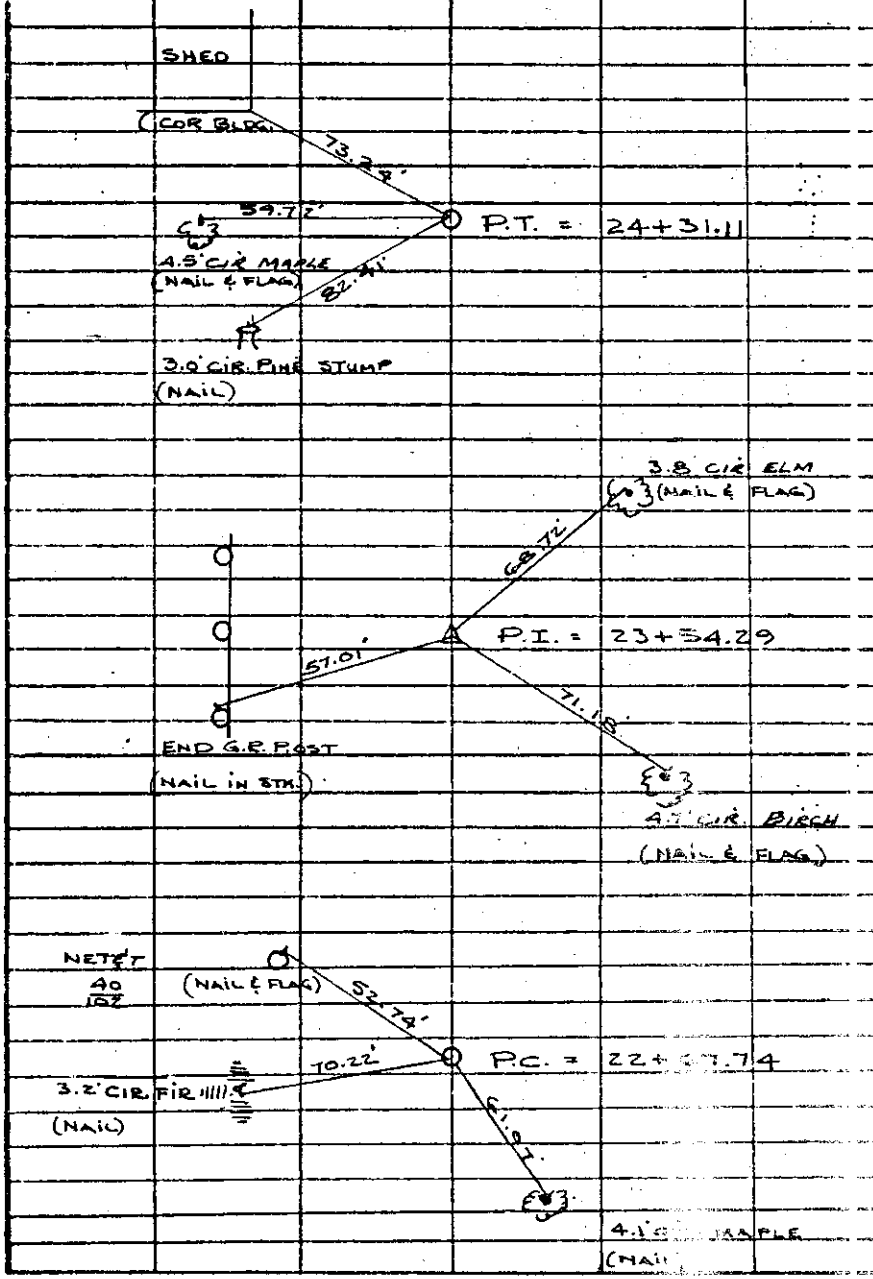
5-9

3

Ties

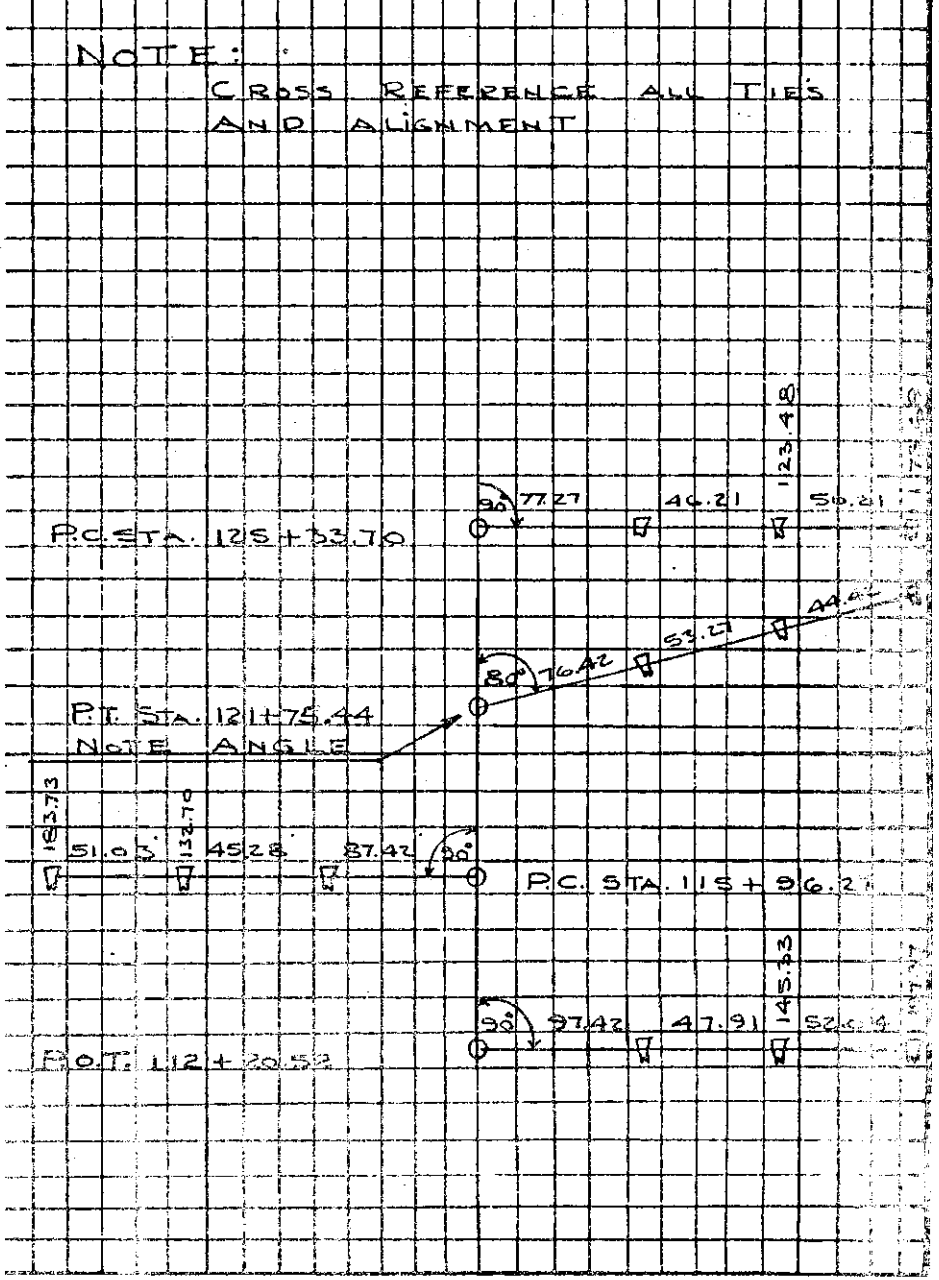
Fair

TYPICAL SWING TIES SKETCH



TYPICAL R.T.A. TIES SKETCH

NOTE:
CROSS REFERENCE ALL TIES AND ALIGNMENT



32

TYPICAL BORING NOTES - LOOSELEAF

FRONT

CAMPTON-FRANCONIA

P-3801

BORING ELEVATIONS

BRIDGE NO. 200/108 S.B.
" " 201/108 N.B.

INTERSTATE 93 OVER

TRIPOLI ROAD

Jan. 4. 1969
Clear-Cold
28" Snow

Black C.P.
Green T
White Ch.
Blue I.

BACK

Sta.		B.S.	H.I.	F.S.	Elev.
BM #822		1.67	801.54		799.87
D.H. #1	N.B.			11.4	720.1
D.H. #2	N.B.			12.7	788.8
D.H. #3	N.B.			10.0	791.5
D.H. #4	N.B.			9.3	792.2
D.H. #5	N.B.			7.8	793.7
D.H. #4	S.B.			16.3	785.2
T.P. #4		4.67	790.79	15.42	786.12
D.H. #3	S.B.			8.0	782.8
D.H. #5	S.B.			6.3	784.5
D.H. #1	S.B.			7.5	783.3
D.H. #2	S.B.			10.0	780.8
T.P. 5		3.80	779.23	15.36	775.43
T.P. 6		5.53	764.47	15.29	763.94
D.H. 7	S.B.			5.6	758.9
D.H. 6	S.B.			18.5	746.0
D.H. 5	S.B.			10.5	754.0

Elevations are from nearest bench mark

BRIDGEPORT
P-1111

Smith C.P.
Brown "
Davis Ch.
Jones L

5-3-72

Fair

Bridge Layout N.B. over Rte. 3A *123/456

DIST.	FIELD	PLAN	TEMP. CORR.	TENSION	TAPE CAL.
①-②	144.17	144.17	+.022	20	25' = 7
②-④	24.23	24.23	+.014	7	50' = 10
②-⑤	31.66	31.66	+.014	8	75' = 12
①-③	24.23	24.23	+.014	7	100' = 16
①-⑤	31.66	31.66	+.014	8	125' = 18
①-④	131.312	*131.362	+.022	18	150' = 20
①-⑥	164.784	*164.818	+.022	21	175' = 24
②-③	159.600	*159.651	+.022	21	200' = 26
②-⑤	128.097	*128.100	+.022	18	
③-④	144.123	*144.17	+.026	20	
		*Cogo.			
A-B	153.79	153.79	+.022		

∠	PLAN	FIELD
①-②-④	53°-54-30	53°-54-30
⑤-Ⓐ-①	49-14-48	49°-14-45

NOTE: 200' CANYON TAPE USED; CAL. TO CANYON TAPE #1 & SPRING GUAGE FROM CONCORD.

■ = TARGETS
△ = HUBS

1990+70.54 N.B. ℄ ABUT. B

1986+77.71 S.B. ℄ & BRG. ABUT. B

FIG. 176.01
TAPED 176.04

1990+14.23 N.B. ℄
* 311+67.11 RTE. 3A CONST. ℄

1986+17.63 S.B. ℄
28+85.04 RTE. 3A CONST. ℄

ROUTE 3A

TO BRIDGEPORT

1985+23.92 S.B. ℄ & BRG. ABUT. 'A'

FIG. 291.45
TAPED 291.39

BRG. △ ABUT. 'A'

1989+26.37 N.B. ℄ ABUT. 'A'

LAYOUT SKETCH BY
LAYOUT SKETCH CHECKED BY:
CHECKED BY RES. ENGINEER:
" " SURVEY SUPERVISOR:
" " LOCATION ENGINEER:

34

BRIDGEPORT
P-1111

Smith C.P.
Brown ⊼
Davis Ck.
Jones ⊥

5-5-72

Bridge Layout Computations # 123/456

Cloudy

4

①

℄ N.B. ℄ (STA. 1990+70.54) To ℄ Brg. Abut "B"

53°-54-30"
107°-48'-25"
161°-42'-30"
215°-36'-30"
269°-30'-30"
6 | 323-24'-25"
53°-54-04.16"

Plan = 53°-54'-30"
⊼ = 53°-54'-04.16"

25.84/60 X .00029 X 118' =
.0147 Corr. applied to obtain Corr. ℄ Brg ⊼

②

℄ S.B. ℄ STA. 1985+23.92 (Abut "A")
To N.B. Abut "A" STA 1989+26.37 N.B.

40°-14-50
98°-29-45
147°-44.40
196°-59-15
246°-13'-35
6 | 295°-28.30"
49°-14'-45"

Plan = 49°-14'-48.75"
⊼ = 49°-14'-45.00"
-03.75 Error

Dist. N.B. ℄ @ Rte. 3-A Const. ℄ x-ings To Abut. "B"

ABUT. "B" N.B. 1990+70.54
N.B. 1990+14.23 @ Rte. 3 ℄ x-ing
56.31

Temp. = 40°
Corr = .018

56.31
.018
1.01358

56. @ 10 Lbs.

Dist. N.B. ℄ @ Rte. 3A Const. ℄ x-ings To Abut. "A"

N.B. 1990+14.23 @ Rte. 3A ℄ x-ing.
Abut. "A" 1989+26.37
87.86

Temp. 47° F
Corr .014

Taped 32.00 @ 8 lbs.
26.00 " 7 "
24.00 " 7 "
82.00
.014
1.148

82.00
0.11
81.989

87.86
- 81.989
5.871 To Abut "A"

Dist. S.B. ℄ @ Rte. 3-A Const. ℄ x-ings To Abut. "B"

Abut "B" S.B. 1986+11.71
S.B. 1986+17.65 @ Rte. 3A ℄ x-ings
60.06

Temp = 34° F
Corr = .022

60.06
.022
1.32132

60.06
.01
60.07 @ 10 Lbs.

BRIDGEPORT

P-1111

Bridge Layout Computations Cont.

Smith C.P.
Brown X
Davis Ch.
Jones ⊥

5-9-72

Fair

5

DIST. TO	S.B. ℄ ABUT. "A"	AT ROUTE 3A CONST. ℄	x-ING		
	S.B. 1986	6+17.65	@ RTE. 3A CONST. ℄ x-ING.		
ABUT. A	S.B. 1985	5+23.92			
		93.73			
				TEMP. = 47° F	
	93.73	93.73		CORR. = .014	
	.014	+ .01			
	1.31222	93.74	@ 15.5 LBS.		

DIST.	℄ BRG.	ABUT. "B", N.B. ℄ TO ℄ BRG.		ABUT B S.B. ℄	
	TAPED	117.66	@ 17 LBS.		
		.018		TEMP. 49° F	
		2.111788		CORR. .018	
	117.66	TAPED	30.00 @ 8 LBS.		
	.02		107.00 " 15.5 "		
	117.64		21.43 " 6 "		
	158.43		158.43		
	- .03		.018		
	158.40		3.05174		
+	117.64				
	276.04				

DIST. TAPED	℄ BRG. ABUT. "A", S.B.	TO ℄ BRG.	ABUT. "A" N.B. ℄		
	150.00	@ 20 LBS.			
	141.52				
	291.52			TEMP. 51° F	
	- .03		291.52	CORR. .011	
	291.49		.011		
			3.20672		

DIST. FROM S.W. COR. OF ABUT. "A" TO N.W. COR. ABUT. "B"

TAPED	81.00	@ 19 LBS.		TEMP. 28° F	
	35.00	@ 8 "		CORR. .026	
	28.16	@ 7 "			
	144.16			144.16	
	.037			.026	
	144.123			3.74816	

DIST. DIAGONAL ① - ④

TAPED	30.00	@ 8 LBS.				TEMP. 34° F	
	23.00	" 7 "				CORR. .022	
	22.00	" 7 "					
	5.00	" 3 "			TAPED	49.34 @ 19 LBS.	
82.00	82.00				49.34	0.22	
.022	.018				.016	1.08554	
1.804	31.982				49.32		
					81.322		
					131.312		

DIST. DIAGONAL ③ - ②

TAPED	75.86	@ 13 LBS.		TEMP. 34° F	
	18.00	" 8 LBS.		CORR. .022	
	34.00	" 8 "			
	31.77	" 8 "			
	159.63			159.635	
	- .038			0.022	
	159.592			3.511370	

BRIDGEPORT
P-1111

Smith C.P
Brown K
Davis G
Jones 1

5-11-72

Clear

Bridge Layout Computations Cont.

DIST.	DIAGONAL	① - ⑥	
TAPED	67.66 @ 11 LBS.		TEMP. 34°F.
	.022	67.66	CORR. .022
	1.48852	-.015	
		67.645	

TAPED	35.00 @ 8 LBS.		97.16
	28.00 " 7 "		.021
	28.00 " 7 "		97.139
	6.16 " 3 "		67.645
	97.16		164.784
	.022		
	2.13752		

DIST.	DIAGONAL	⑤ - ②	
TAPED	62.30 @ 11 LBS		TEMP. = 34° F
	.022	62.30	CORR. .022
	1.37060	.014	
		62.286	

TAPED	20.00 @ 6 LBS.		
	19.00 " 6 "		65.825
	21.00 " 6 "		- .014
	5.825 " 3 "		65.811
	65.825		62.286
	.022		128.097
	1.448150		

DIST. NBE @ ABUT "A" & "B" TO W.P.'s TO THE LEFT.

24.23	24.33	TEMP.: 47°F
.014	.003	CORR. .014
.339220	24.235 @ 7 LBS.	

DIST. NBE @ ABUT "A" & "B" TO W.P.'s TO THE RIGHT

31.666	31.66	TEMP.: 47°F
.014	+ .004	CORR. .014
.443324	31.664 @ 8 LBS.	

Campton — Thornton

P – 7889 – A

R.O.W. Bound List

Jones
Smith
Davis
Brown

Jan. 18, 19

Clear – Cold

3

Note: Record date when bound is staked.

P.o.T.	1371+	15.37	End Project	1/18/7 150' R/W	150' R/W 1/18/7
P.o.T.	1363+	50		1/17/7 R/W	150' R/W 1/
P.o.T.	1353+	50		1/17/7 R/W	150' R/W 1/
P.o.T.	1350+	25.11	(On property line)		150' R/W 1/
P.o.T.	1343+	50		12/7/7 25' 125' 150' R/W	150' R/W 12/
P.T.	1335+	67.21		12/7/7 25' 125' 175' R/W	150' R/W 12/
P.o.C.	1327+	50.30		12/7/7 150' R/W	150' R/W In River, Ref. Bound 12/
P.C.	1325+	50.30	(Reference bound @ 175' Rt.)	12/6/7 150' R/W	150' 175' 25' R/W
P.o.T.	1320+	50		12/6/7 150' R/W	150' R/W 12/
P.o.T.	1312+	00.95	Begin Project	12/5/7 150' R/W	150' R/W 12/

SIX GUN CITY
P-6666

Orig. Ledge Sections

Dillon
Earp
James
Holiday

12-2

Fair

Sta.	B.S.	H.I	F.S.	Elev.	
LEGEND:					
	E.L.=EARTH to LEDGE				
	L.E.=LEDGE to EARTH				
B.M.#10	5.63	536.90			531.27
25+0					
25+25					
25+37					
25+50					
T.P.#1			1.67	535.23	

PLAN

	L.E.	L.	L.	L.	L.	L.	L.E.
	17	19	℄	12	24	38	54
	9.2	10.0	10.0	7.2	9.1	9.7	10.0

	L.E.	L.	L.	L.	L.	L.	L.E.
2.6	2.7	12	℄	11	23	36	52
3.0	3.4	10.0	9.6	8.4	9.0	8.7	9.0

	L.E.	L.	L.	L.	L.	L.	L.E.
58	1.6	2.8	1.3	17	℄	13	26	38	47
2.0	3.7	4.2	3.3	3.7	4.2	3.0	3.8	4.2	5.0

	L.E.	L.	L.	L.	L.	L.	L.	L.	L.E.
64	5.6	5.0	1.2	12	℄	15	26	39	46
0.0	1.4	1.0	1.3	2.3	2.7	2.5	2.2	2.9	3.5

Point of Ledge 25+58 Lt. 24'

CONTINUE TO END OF STRIPPED LEDGE.
A ZERO SECTION SHOULD BE TAKEN, UNLESS MORE LEDGE IS TO BE TAKEN BEFORE DATE.

COOPERSTOWN
P-1234

Jones
Smith
Davis
Brown

2-2-

Snow Depth = 24" 3

Side Stake Levels "A" Ramp

	These	Notes on looseleaf only				
BM. 106	16.67	118.99			102.32	Book 9868 Pg. 21
Sta.	offset		reading	elev.	F.G.	
2-A					112.52	
	50-L		7.40	111.59		F= 0.93
	70-L		7.81	111.17		F= 1.35
+50					11.26	
	50-L		7.60	111.39		C= 0.13
	70-L		8.02	110.97		C= 0.29
3-A					10.00	
	45-L		7.97	111.02		C= 1.02
	65-L		8.33	110.66		C= 0.66
+50					08.74	
	50-L		8.04	110.95		C= 2.21
	45-R		6.20	12.79		C= 4.05
4-A					07.48	
	50-L		8.19	110.80		C= 3.32
	50-R		7.01	111.98		C= 4.50
T.P.#1	9.20	119.99	8.20	110.79		@ Sta. 4+[illegible]-A
4-A+50					106.22	
	55-L		10.20	109.79		C= 3.57
	55-R		11.47	108.52		C= 2.30
5-A					04.96	
	60-L		12.04	107.95		C= 2.99
	60-R		13.20	106.79		C= 1.83
+50					03.70	
	50-R		14.27	105.72		C= 2.02
	50-R		15.60	104.39		C= 3.69
B.M.#6-A			12.86	107.13	107.[illegible]	Back 3-[illegible] Pg. 30

EAST OVERSHOE
P-1000

Shutz Gravel Pit #1 Layout

Jones C.F.
Davis
Smith
Brown

4-13-72

showers 3

B.M.#1	40+08	504 Vert.	S.&W.– 47' Pine	= 456.78
B.M.# 2	44+77	578 "	" " 30' Maple	= 470.00

NOTE:

Pit Location; From field office go east 1.2 miles along Rte.69. Pit is on north side of hwy.

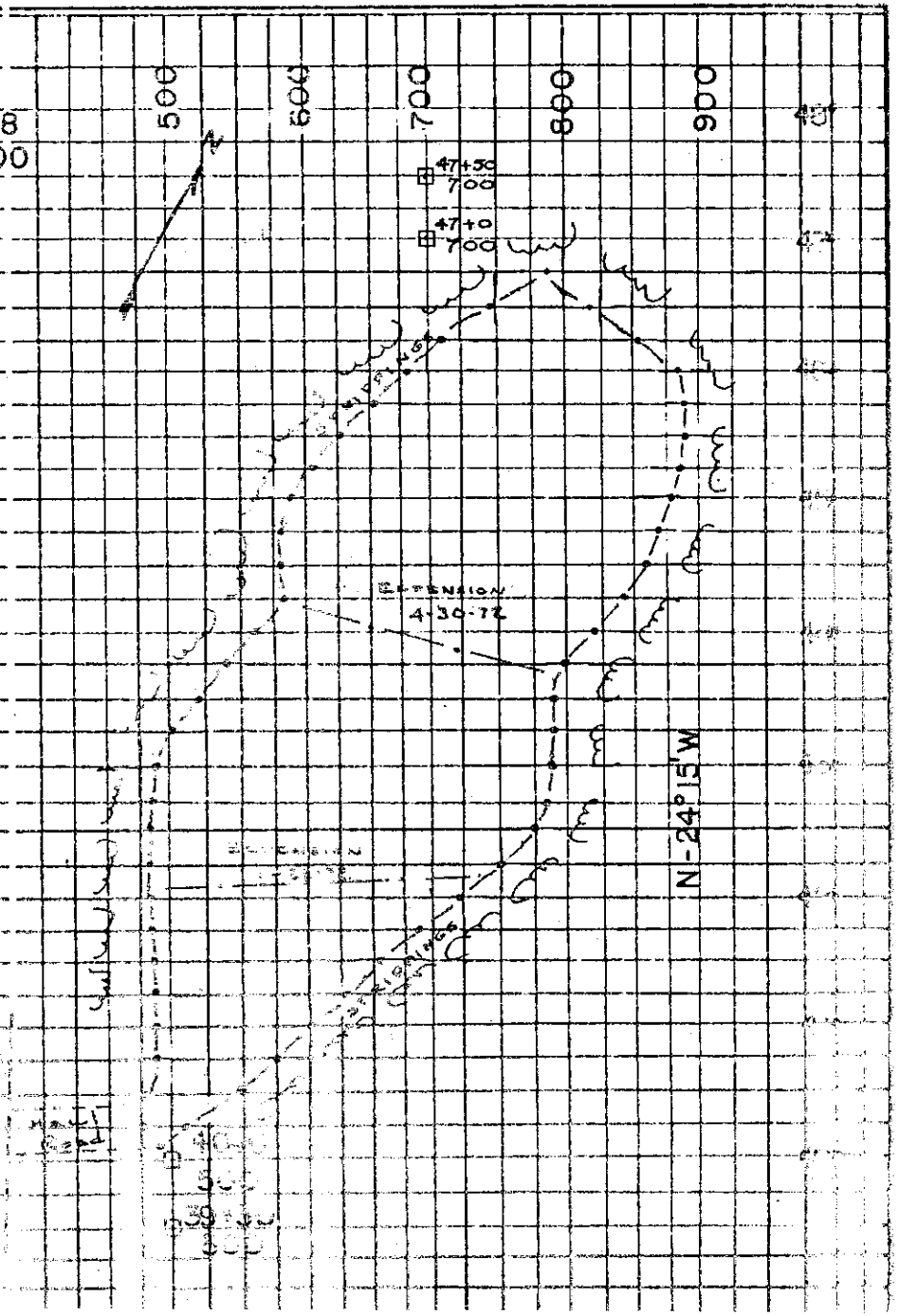
Owner; Albert Shutz
22 Main St.
East Overshoe, N.H.

Pit stripped of all overburden.

Hub symbol = ⊡

SPECIAL NOTE:

If pit is within 500' of centerline it must be tied in vertically as well as horizontally.



EAST OVERSHOE
P-1000

JONES C.P.
SMITH "
DAVIS CK.
BROWN ⊥

12/18, .1

ORIGINAL SECTIONS SHUTZ GRAVEL #1

CLOUDY
12" SNOW

3

Sta.	B.S.	H.I.	F.S.	Elev.		
BM#69	7.99	109.00		101.01	101.01	VERT. SPK ROOT 24" CIR MAPLE STA 69+45 75' RT.
	FOR	LAYOUT	SEE	PG. 2		SEE NB 7221 - PG. 32
20+80	ZERO	SECTION	BACK			
			WASTE		E.S.	
21+00	DO NOT		525	527	530	550 575 600 625 650 665
			4.9	4.9	7.2	12.2 12.8 13.2 14.7 15.0 12.0
	USE 2nd or					
	3rd. COLUMN					
				E.S.	WASTE	
21+00			668	670	673	
			10.2	8.2	7.0	
			WASTE		E.S.	
21+25			490	495	495	500 525 CONT. PG. 6
			5.2	5.3	8.9	14.2 16.2
			WASTE		E.S.	
21+50			475	479	481	500 CONT. PG. 6
			5.7	6.0	9.2	16.4

GILFORD
P-0000

Final Sections Mann Pit – Gravel # 3

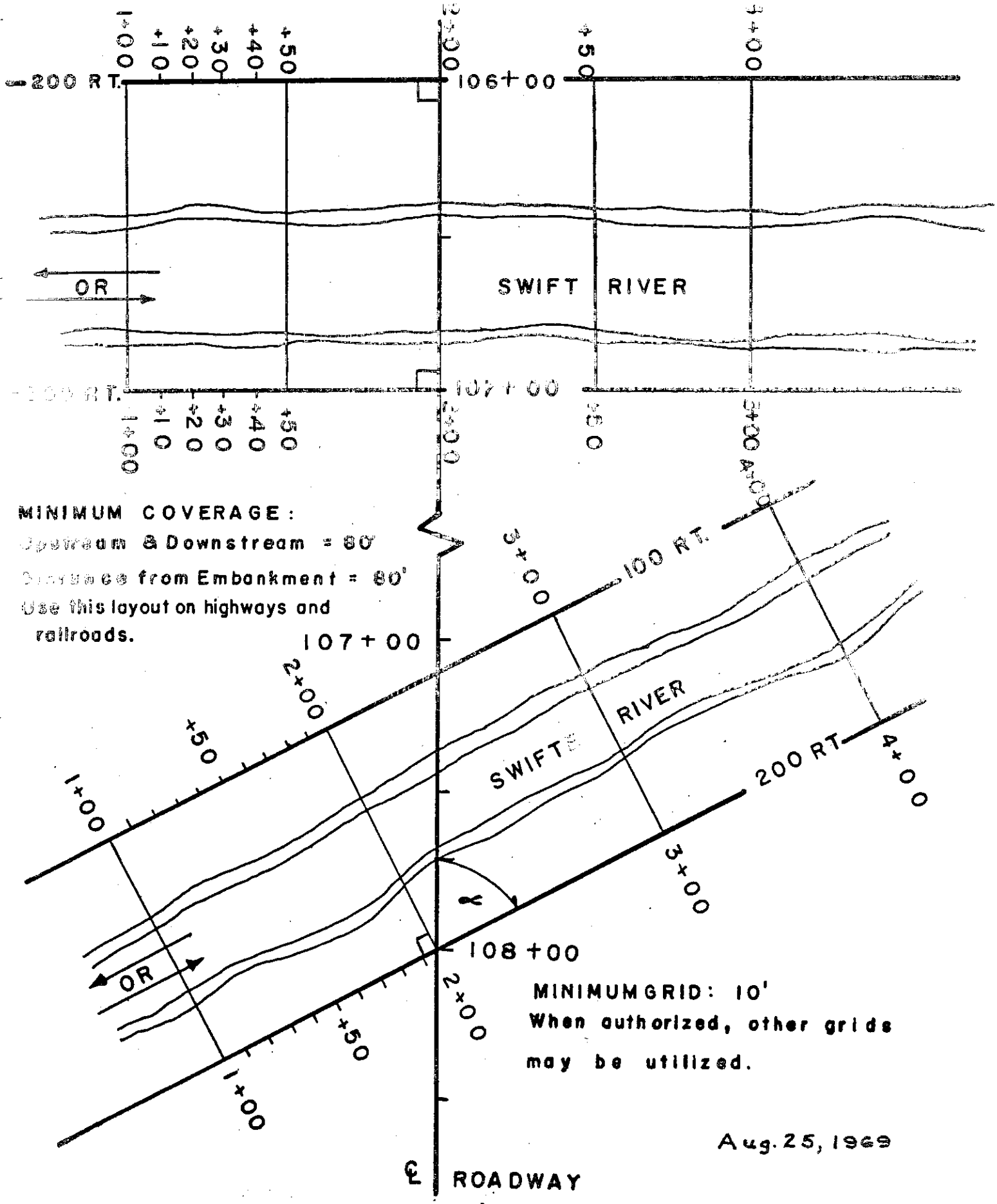
Black Ch.
White
Black Ch.
Green 1

4-. 12

Fair 3

	B.S.	H.I.	F.S.	Elev.								
B.M.#50	3.76	216.97		213.21		Pg. 21 this book						
52+60			Zero Section									
			O.G.	E.P.						E.P.	O.G.	
52+75			525	538	546	550	575	600	612	617	625	
			1.7	1.9	10.2	10.0	9.5	9.6	9.0	1.1	1.2	
			0.G	E.P.								
53+0			500	517	521	525	540	575	600	625	650	
			2.0	1.9	9.8	10.6	9.1	9.8	10.0	9.8	10.0	
			E.P.	O.G								
53+0			667	675								
			2.7	2.6								
			O.G.	E.P.				E.P.	O.G.			
53+25			550	563	575	600	625	638	650			
			1.9	1.8	9.7	10.1	9.5	2.3	2.6			
53+40			Zero	Section								
BM #51			6.00	210.97	210.38	Pg. 27 this book						

TYPICAL GRID LAYOUT



MINIMUM COVERAGE:

Upstream & Downstream = 80'

Distance from Embankment = 80'

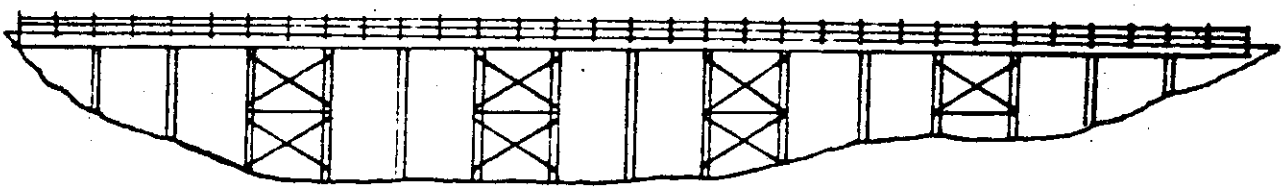
Use this layout on highways and railroads.

MINIMUM GRID: 10'

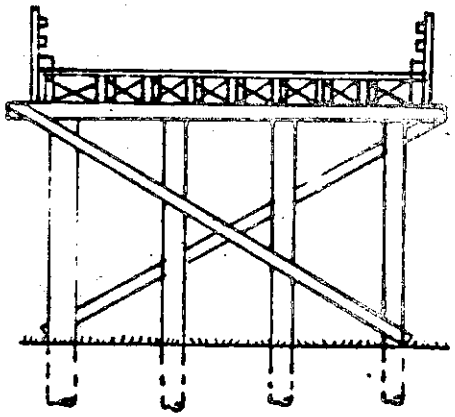
When authorized, other grids may be utilized.

Aug. 25, 1969

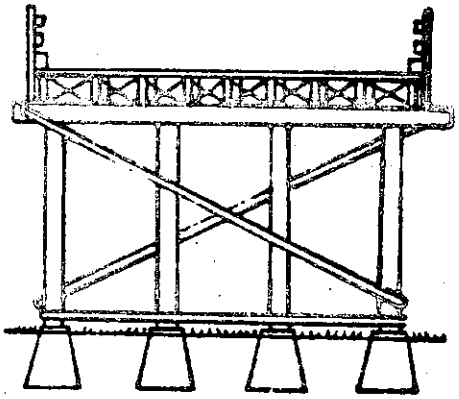
GENERAL BRIDGE TYPES



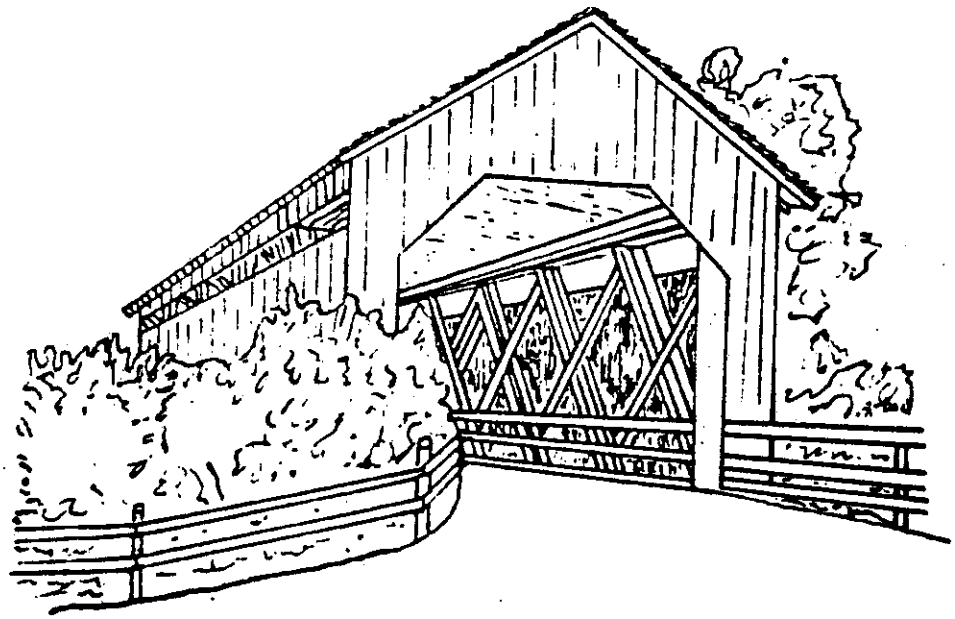
TIMBER TRESTLE



PILE BENT

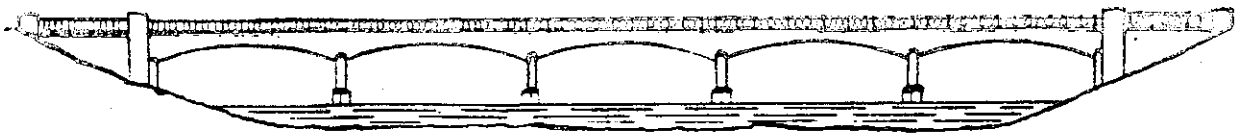


FRAME BENT



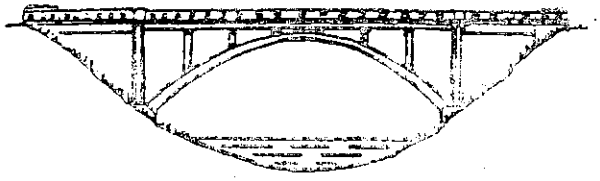
COVERED BRIDGE

GENERAL BRIDGE TYPES

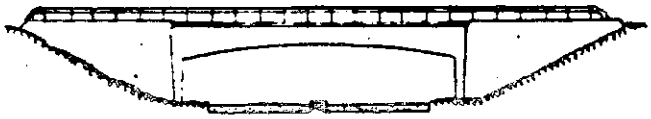


CONTINUOUS GIRDER

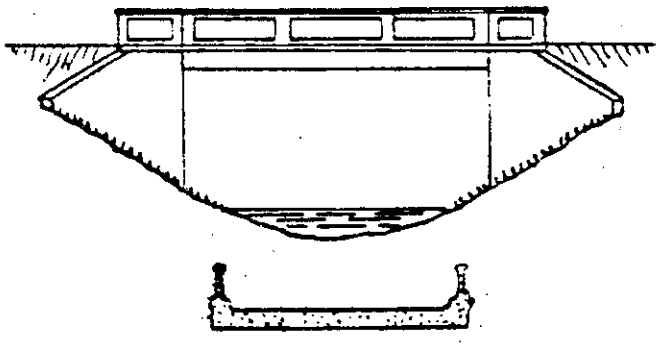
SPANDREL-FILLED ARCH



OPEN SPANDREL ARCH

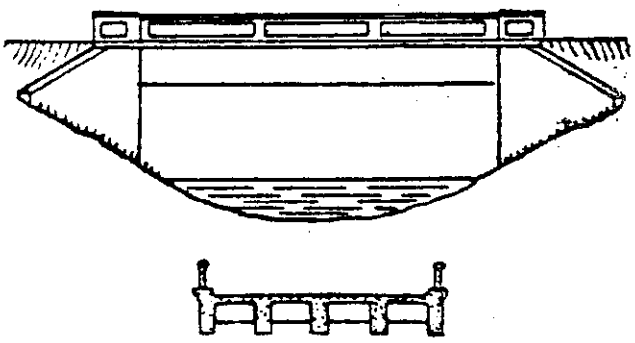


RIGID FRAME-CONCRETE



SLAB SECTION

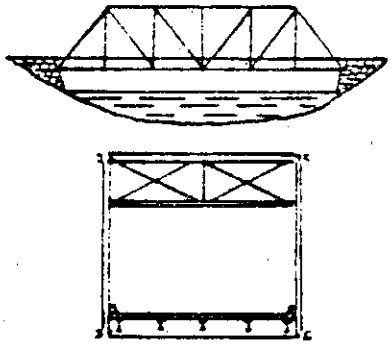
CONCRETE SLAB (PLAIN)



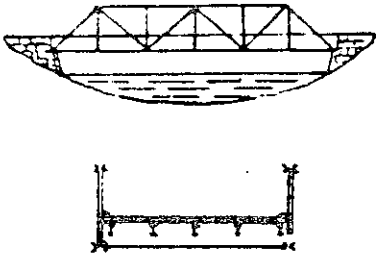
T-BEAM SECTION

CONCRETE T-BEAM

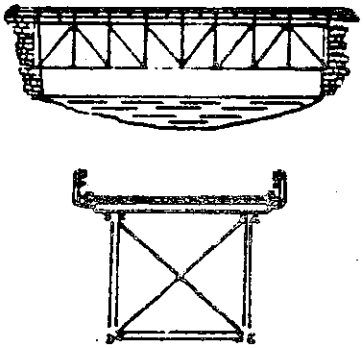
GENERAL BRIDGE TYPES



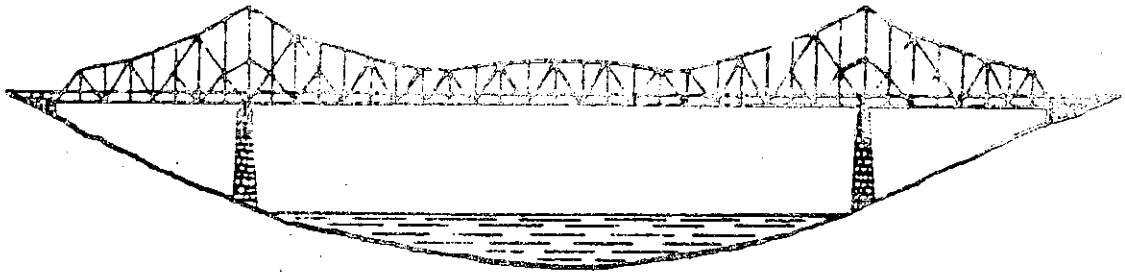
THROUGH TRUSS



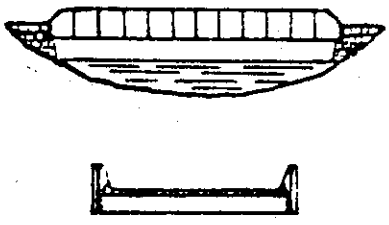
PONY TRUSS



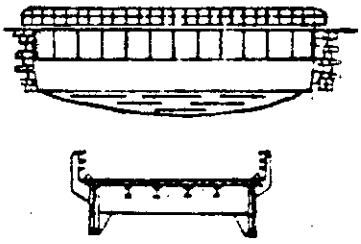
DECK TRUSS



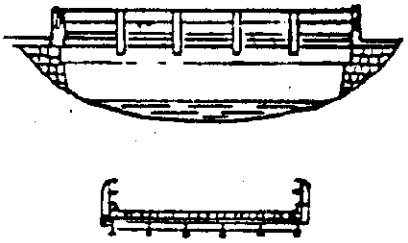
CANTILEVER



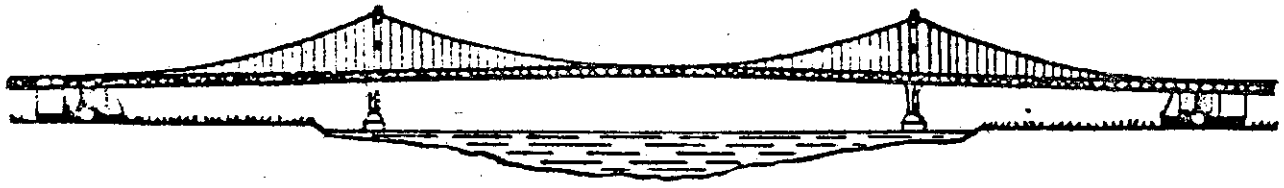
THROUGH GIRDER



DECK GIRDER

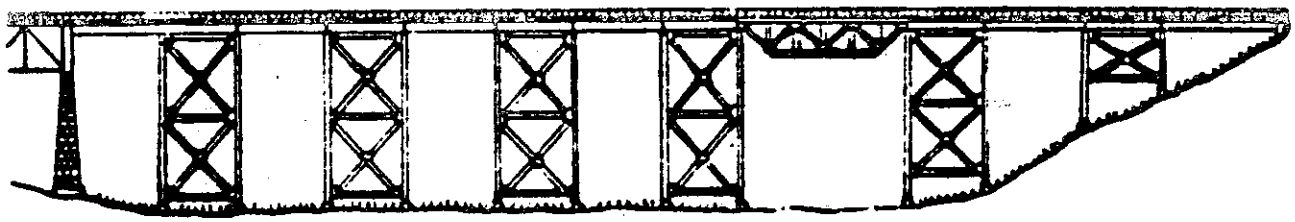


I BEAM

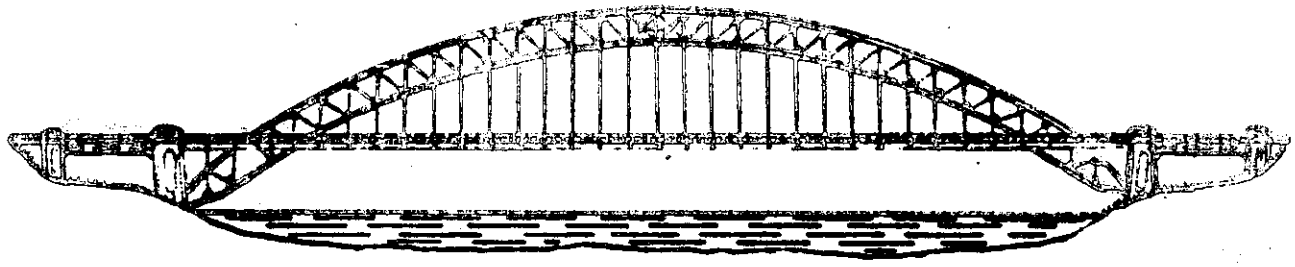


SUSPENSION

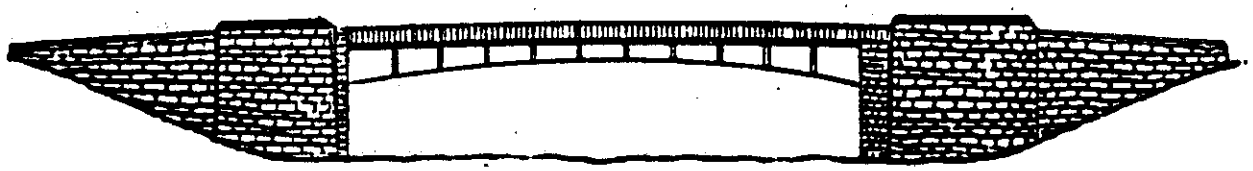
GENERAL BRIDGE TYPES



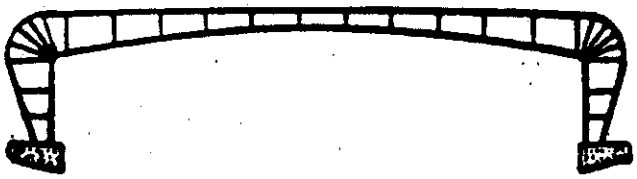
STEEL VIADUCT



THROUGH-ARCH TRUSS



RIGID FRAME-STEEL



RIGID FRAME
(STEEL GIRDER ELEMENT)

STRUCTURAL — TRUSSES

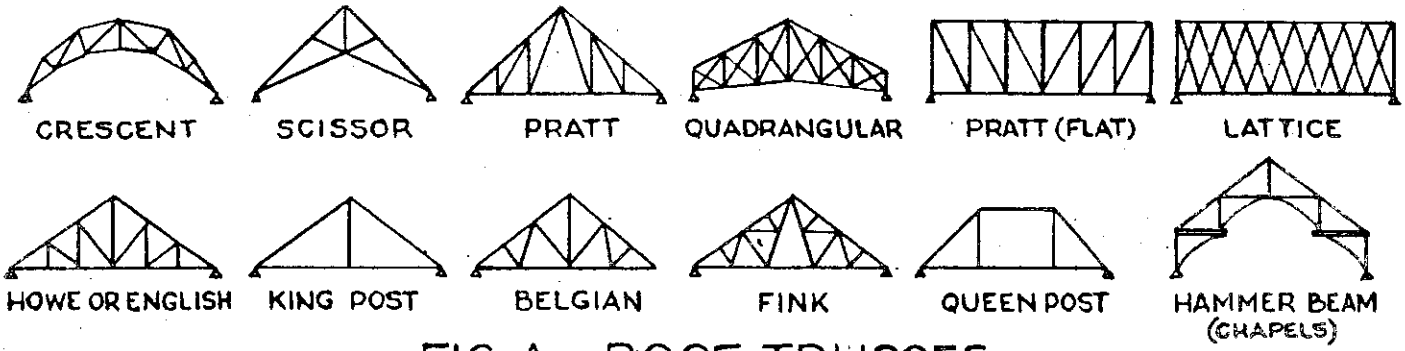


FIG. A ROOF TRUSSES

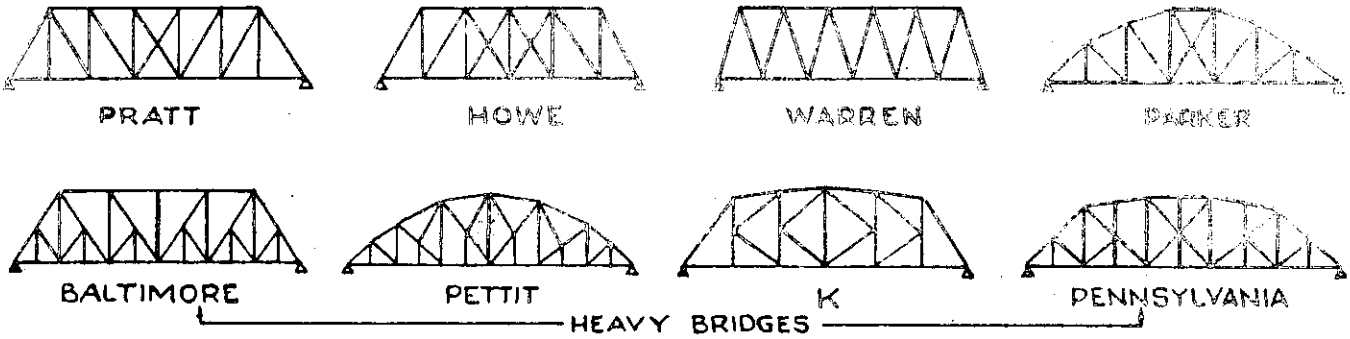
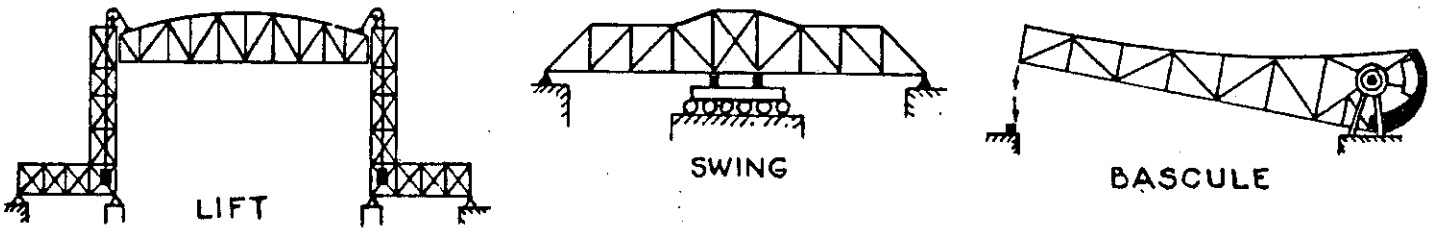
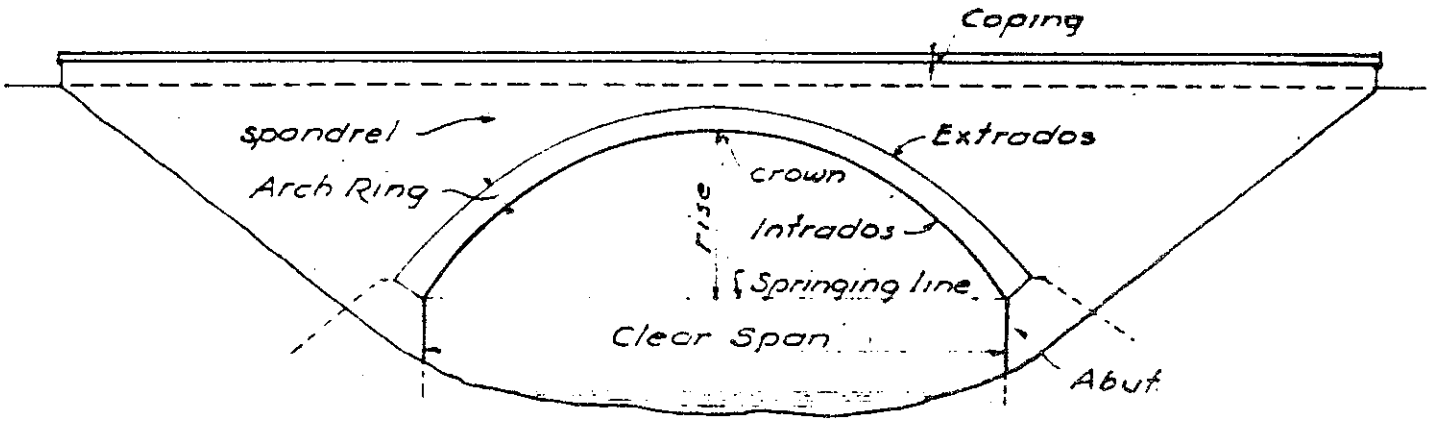


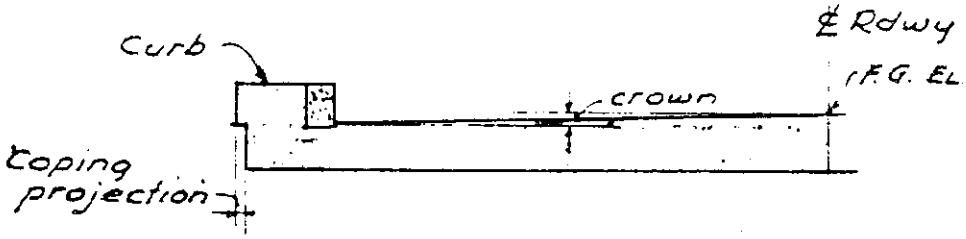
FIG. B BRIDGE TRUSSES

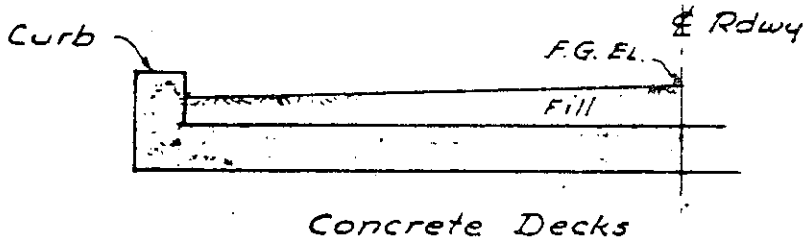


FUNDAMENTAL BRIDGE NOMENCLATURE

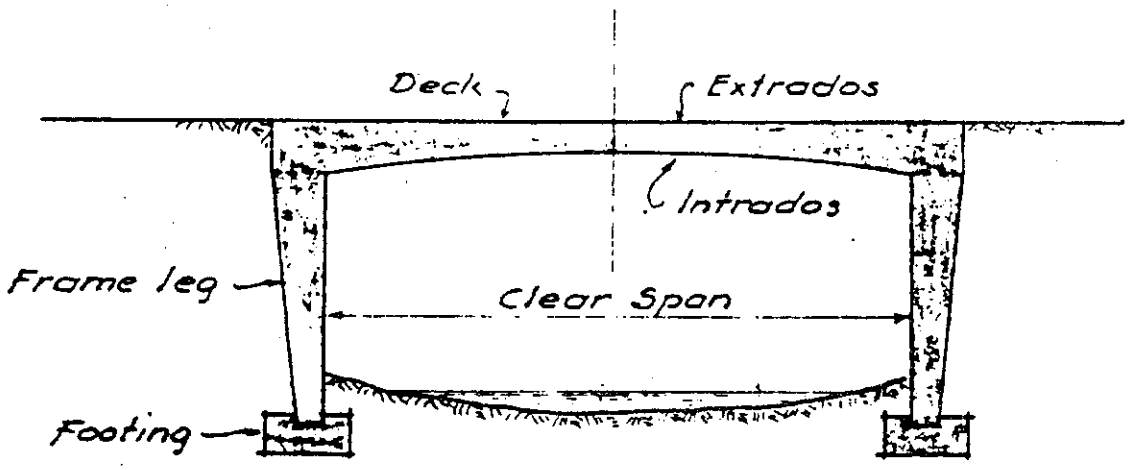


Arch



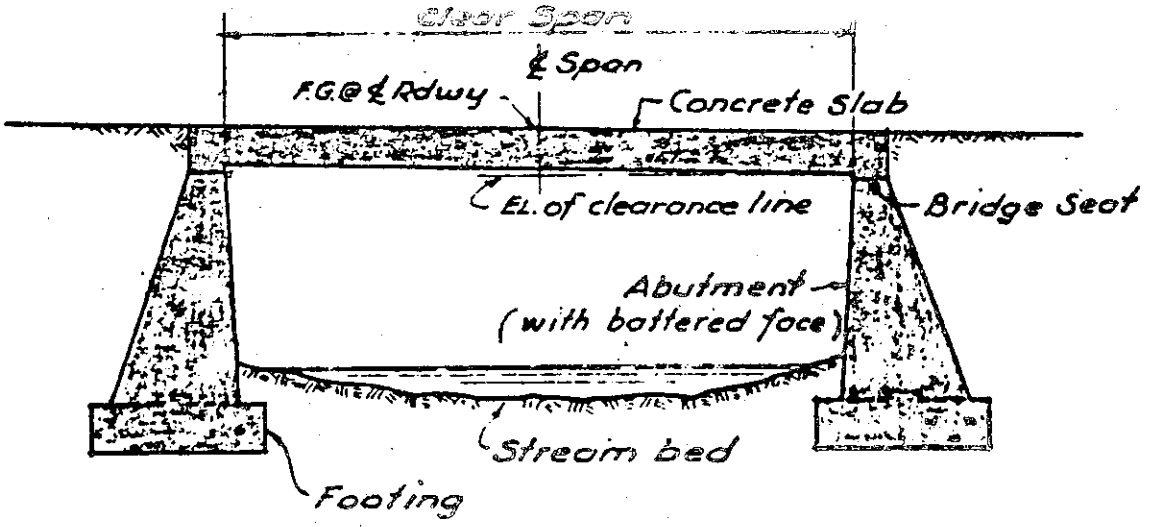


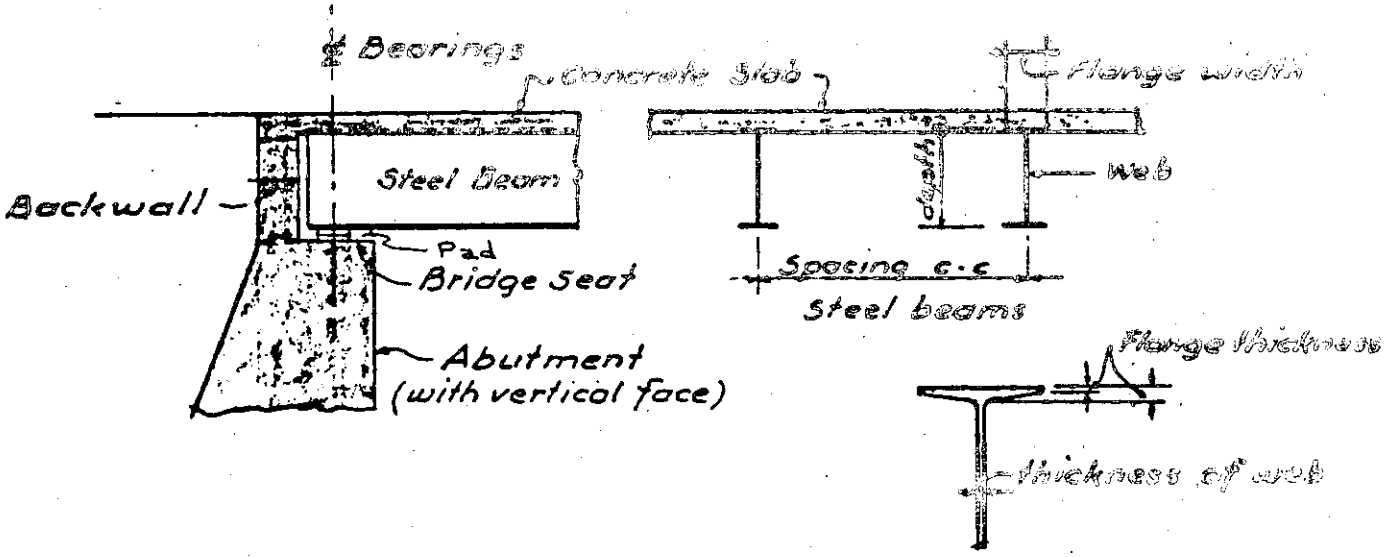
Concrete Decks

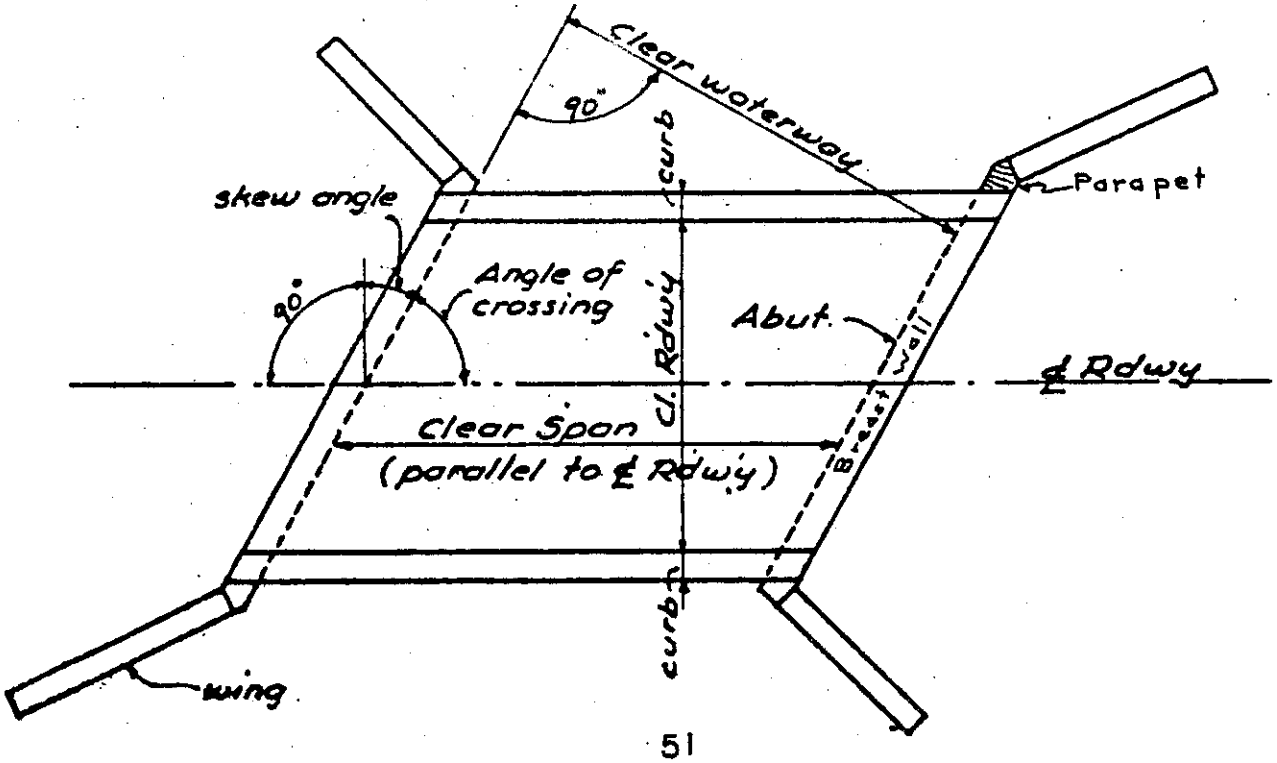


Concrete Frame

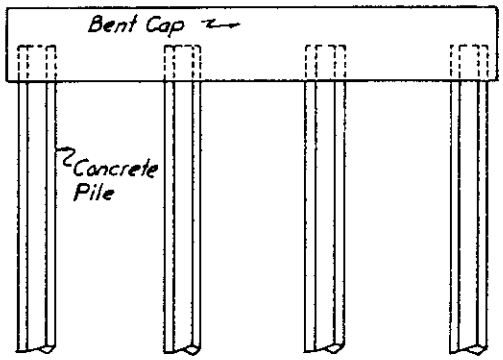
FUNDAMENTAL BRIDGE NOMENCLATURE



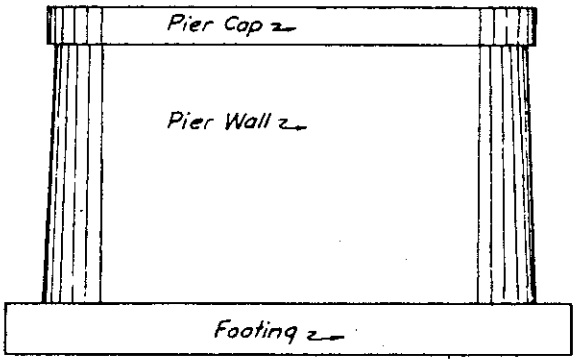




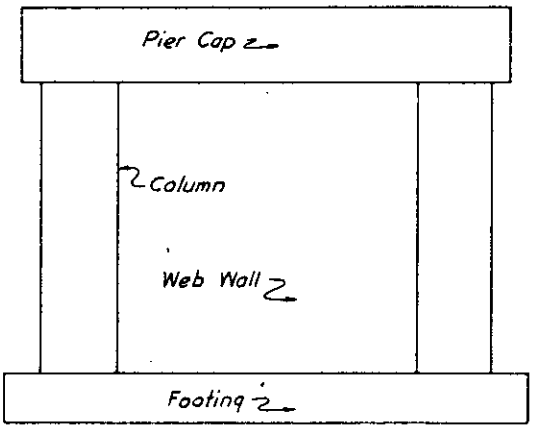
FUNDAMENTAL BRIDGE NOMENCLATURE



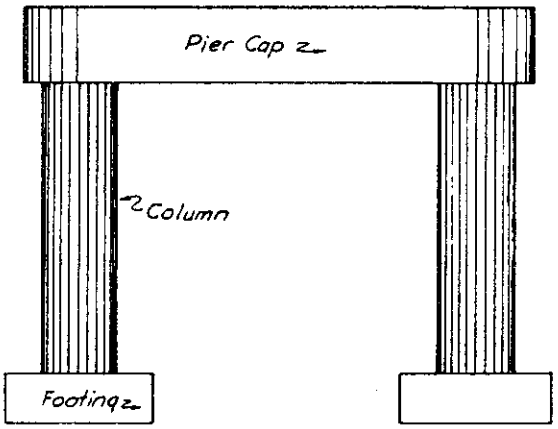
PILE BENT



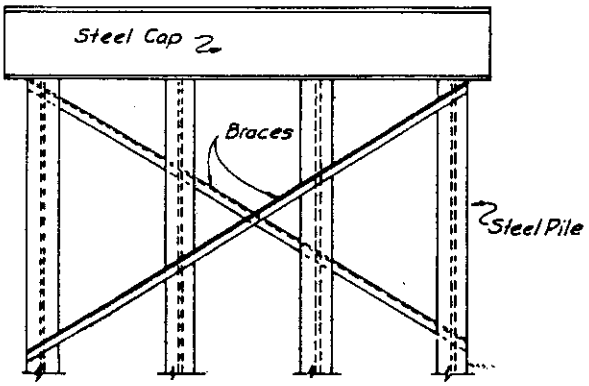
SOLID PIER



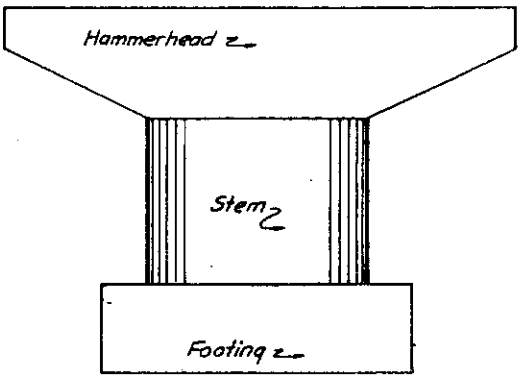
COLUMN PIER WITH SOLID WEB WALL



COLUMN BENT OR OPEN PIER

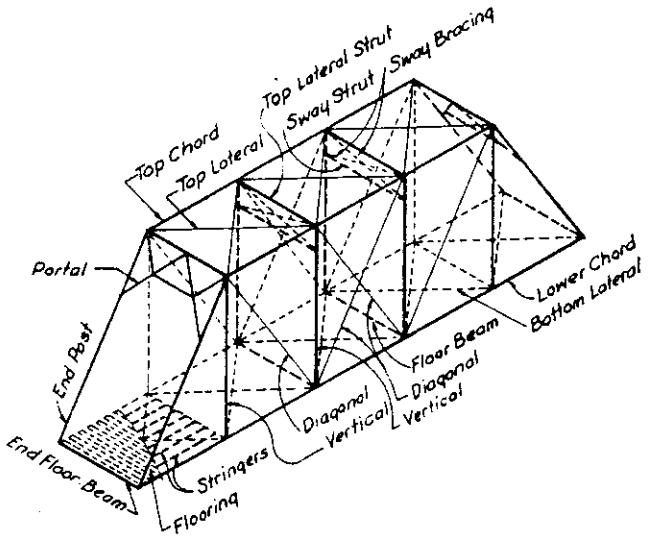


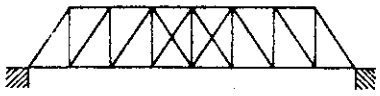
STEEL BENT



CANTILEVER PIER OR HAMMERHEAD PIER

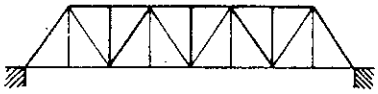
FUNDAMENTAL BRIDGE NOMENCLATURE



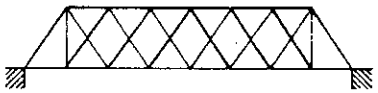


THROUGH HOWE TRUSS

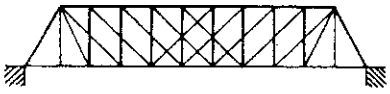
THROUGH PRATT TRUSS



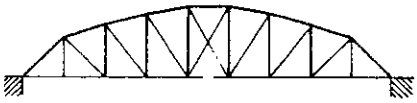
THROUGH WARREN TRUSS



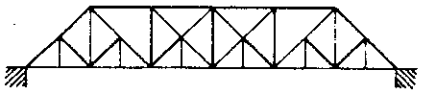
QUADRANGULAR THROUGH WARREN TRUSS



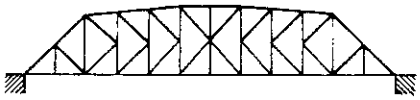
THROUGH WHIPPLE TRUSS



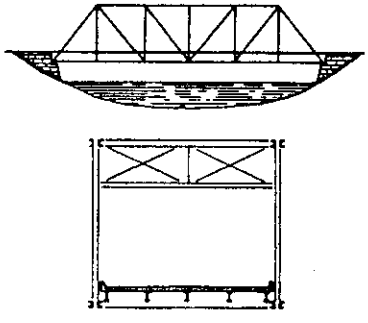
CAMEL BACK TRUSS



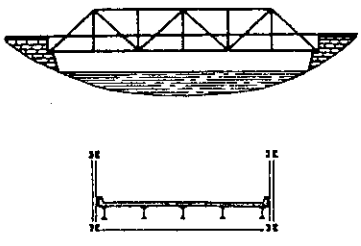
THROUGH BALTIMORE TRUSS



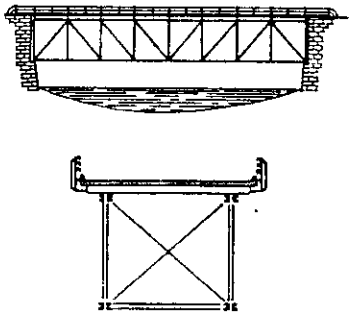
K - TRUSS



THROUGH TRUSS

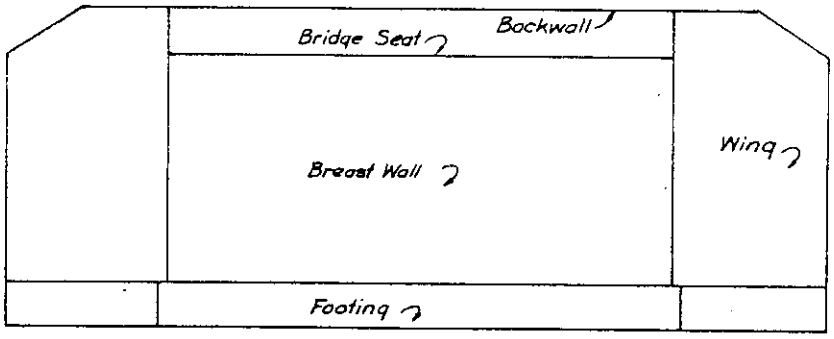


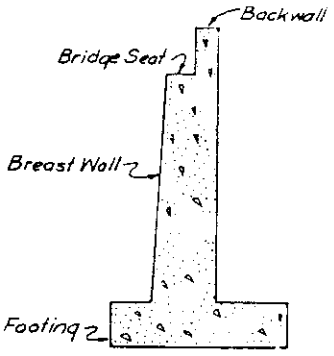
PONY TRUSS



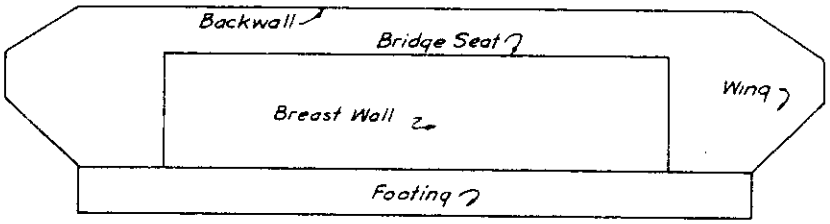
DECK TRUSS

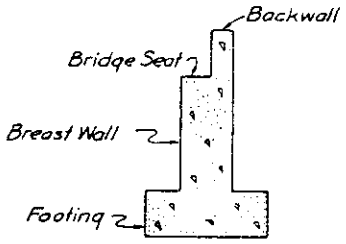
FUNDAMENTAL BRIDGE NOMENCLATURE



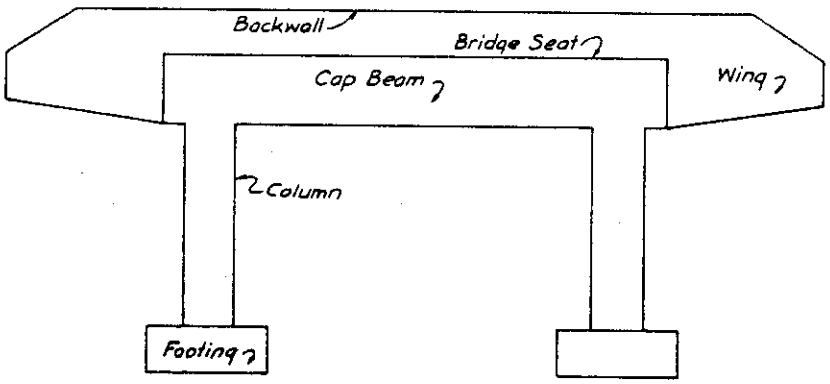


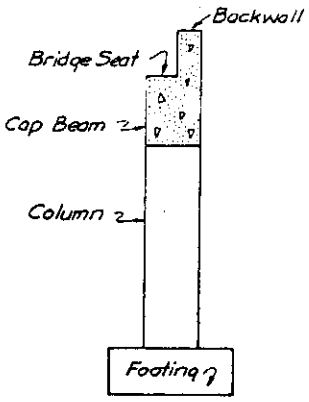
FULL HEIGHT ABUTMENT





STUB ABUTMENT

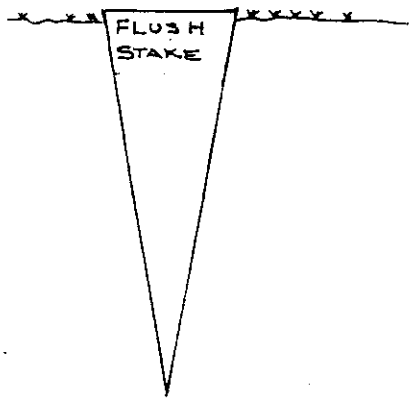




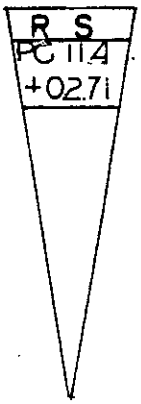
OPEN ABUTMENT

STAKE MARKING CODE

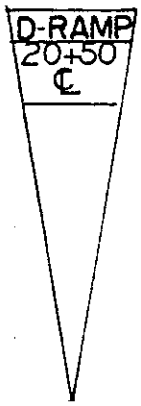
℄ STAKE



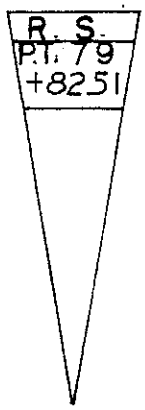
℄ REFERENCE STK.



RAMP ℄ STK.

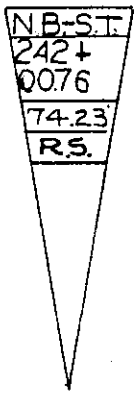


RAMP REFERENCE STK

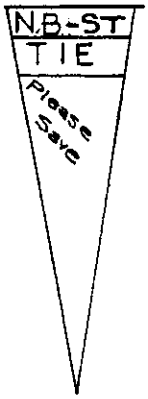


℄ TIES REFERENCE STKS

Front

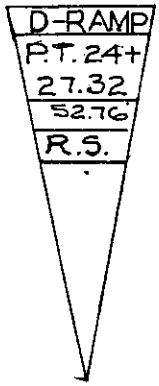


Back



RAMP ℄ TIES REFERENCE STKS

Front



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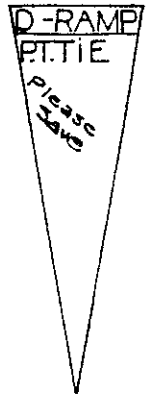
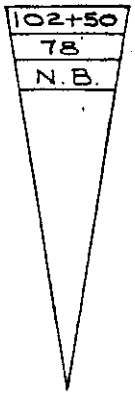


SIDE STAKES

Front



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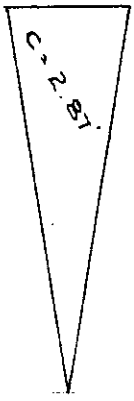
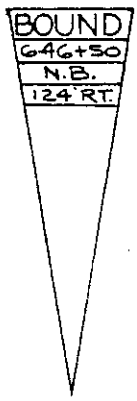
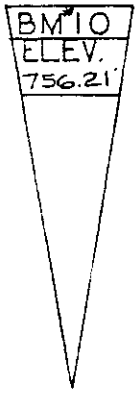


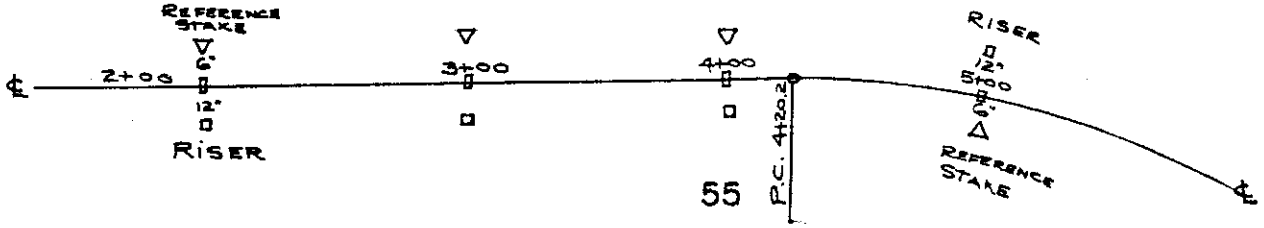
BOUND



BENCH MARK



PLACEMENT OF STAKES

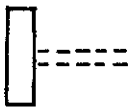
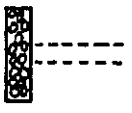
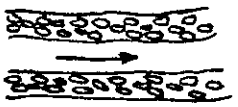


STANDARD SYMBOLS

BOUNDARY LINES

Property Line	JOHN SMITH / MILES STANDISH
Town Line	BOW / CONCORD
County Line	COOS / GRAFTON
STATE LINE	MAINE / NEW HAMPSHIRE
Iron Pipe or Pin	● I.P.
Stone Bound	□ S.B.
Right of Way Bound	□ R/W
Reference Monument	⊡ R.M.
Vertical or Horizontal Station	△ USGS, USC & GS, etc.
Project Marker	△ P.M.

DRAINAGE

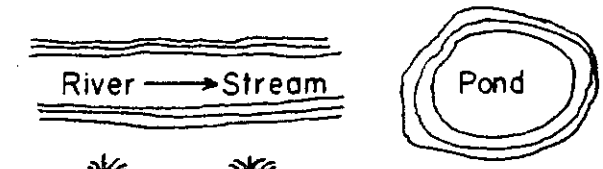
Catch Basin	⊜ C.B.
Drop Inlet	⊟ D.I.
Culvert	::::::::: note size & type
Underdrain	U═══U═══U═══U label size & type
Header, Concrete	
Header, M.R.M. or Stone	
Open Ditch	
Slope Paving or Rip Rap	

STANDARD SYMBOLS

GENERAL CULTURE

Water Course

Shore Line

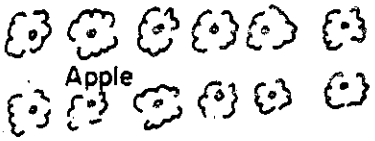


Swamp or Marsh

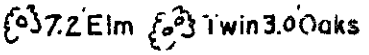
Stump

Brush Line, Woods

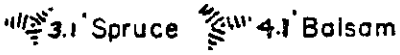
Orchard



Trees, Typical Hardwood

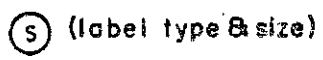


Trees, Typical Softwood



Hedge

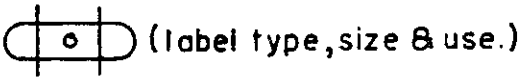
Septic Tank



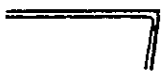
Leach Field

Gas Pumps

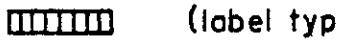
Storage Tanks



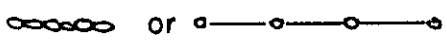
Curb



Steps



Stone Wall



Retaining Wall

STANDARD SYMBOLS

UTILITIES

Telephone Pole

Power Pole

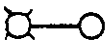
Bar parallel to direction of line
Insert "T" to signify transformer

Joint Occupancy

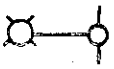
Circle within square

Guy Pole

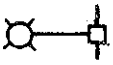
Light Pole



Light on telephone pole



Light on power pole



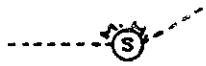
Traffic Signal

Hydrant

Manhole

Label: SMH, TMH, WMH etc.

Underground Utilities

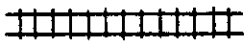


Label type & size

Gates, Valves, & Shutoffs

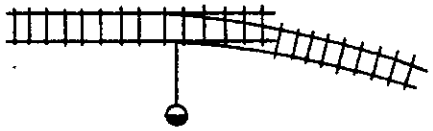
Label: W.G., W.S.O., G.S.O. etc.

Railroad

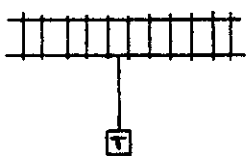


R.R. Sign or Signals

R.R. Switch



R.R. Transformer



Mile Post

STANDARD SYMBOLS

Fence, Barbed Wire

Fence (label type)

Cemetery — Cem.

Well (label type, size & depth)

Building — 20.0 Gar. 20.0; 40.0 Barn 20.0; 36.2 2 Sto. Wd. Fr. Ho. 45.0

Note cellar & type of found.
Cross-hatch cellar area.

Foundation — 22.5 Conc. 20.0

Guard Rail — Label: beam, etc.

Roadway — Label type

Driveway — Label type

Bridge Crossing (Stream)

Highway Overpass

Highway Underpass

Ledge Outcrop

Bridge Target

HORIZONTAL AND VERTICAL SPECIFICATIONS

HORIZONTAL

First Order = $0.66' \sqrt{M}$ or 1' in 25,000'

Second Order = $1.67' \sqrt{M}$ or 1' in 10,000'

Third Order = $3.34' \sqrt{M}$ or 1' in 5,000'

M is the distance in miles.

VERTICAL

First Order = $0.17' \sqrt{M}$

Second Order = $0.35' \sqrt{M}$

Third Order = $0.50' \sqrt{M}$

M is the length of the run in miles.

OFFSET CURVES

1. If an offset line is to be run, as in stake-out for fine grading., it is desirable that the stationing on the offset line remain normal to ℄ stationing.
2. The chord measured to each station must be corrected to obtain this result.
3. The relationship between OFFSET and CENTER-LINE CHORDS is DIRECTLY PROPORTIONAL to the relationship of the OFFSET and CENTER-LINE curve RADII.

C = Chord on ℄ curve
R = Radius of ℄ curve
Co = Chord on Offset curve
Ro = Radius of Offset curve

$$\frac{Co}{C} = \frac{Ro}{R}$$

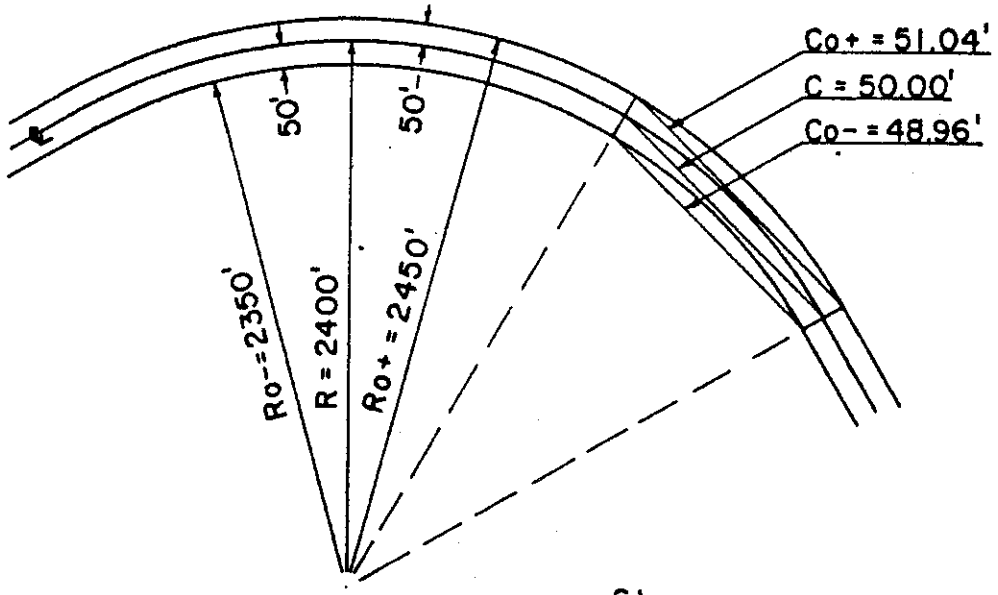
Example:
R = 2400'
offset lines = 50' L and R

for 1' chord inside of ℄
$\frac{Co}{1'} = \frac{2350'}{2400'} = 0.97917'$

for 50' chord measure
50' X 0.97917 = 48.96'

for 1' chord outside of ℄
$\frac{Co}{1'} = \frac{2450'}{2400'} = 1.02083'$

for 50' chord measure
50' X 1.02083 = 51.04'



SLOPE CHAINING

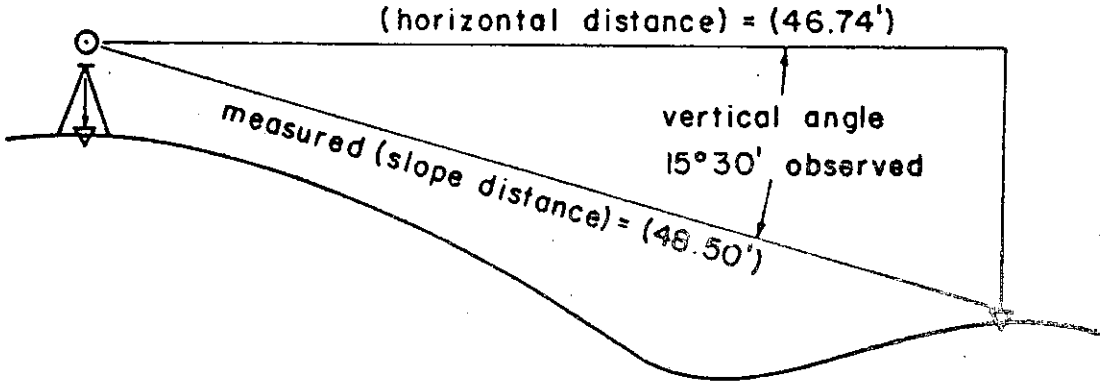
I. Vertical Angle to Hub and Tack

Formula: (slope distance) X (cosine of vertical angle) = (horizontal distance)

Note: Always check "0" reading of vernier with telescope level.

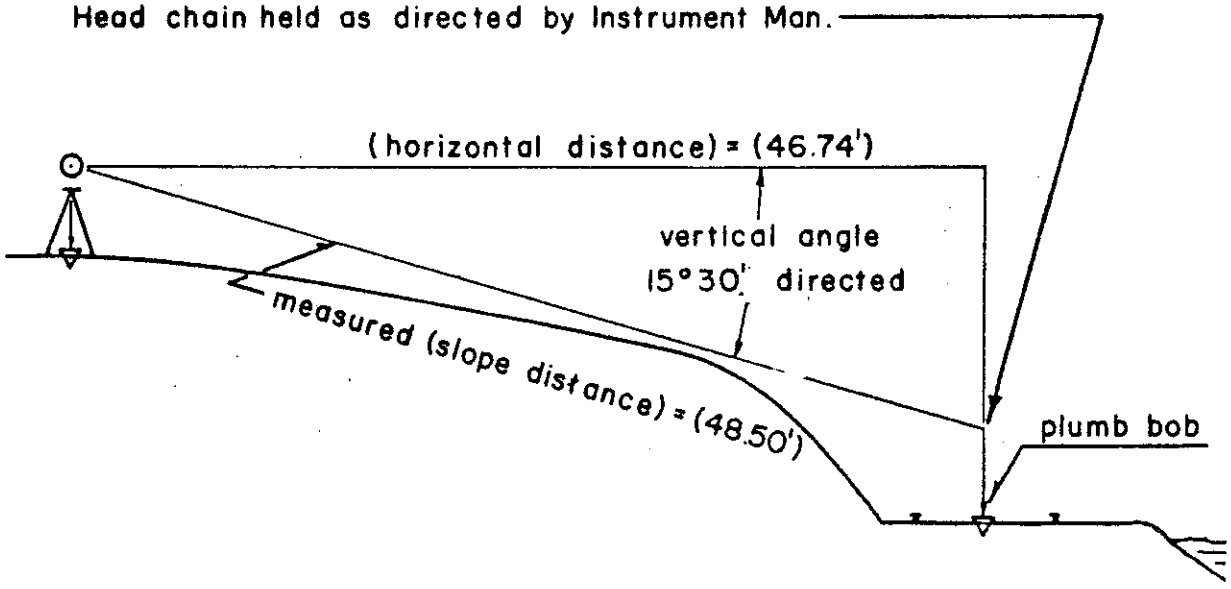
Example: (48.50') X (cosine of 15°30') =

(48.50') X (.96363) = (46.74')



II. Vertical Angle as directed by Instrument Man when method I is impractical due to obstructions.

Head chain held as directed by Instrument Man.



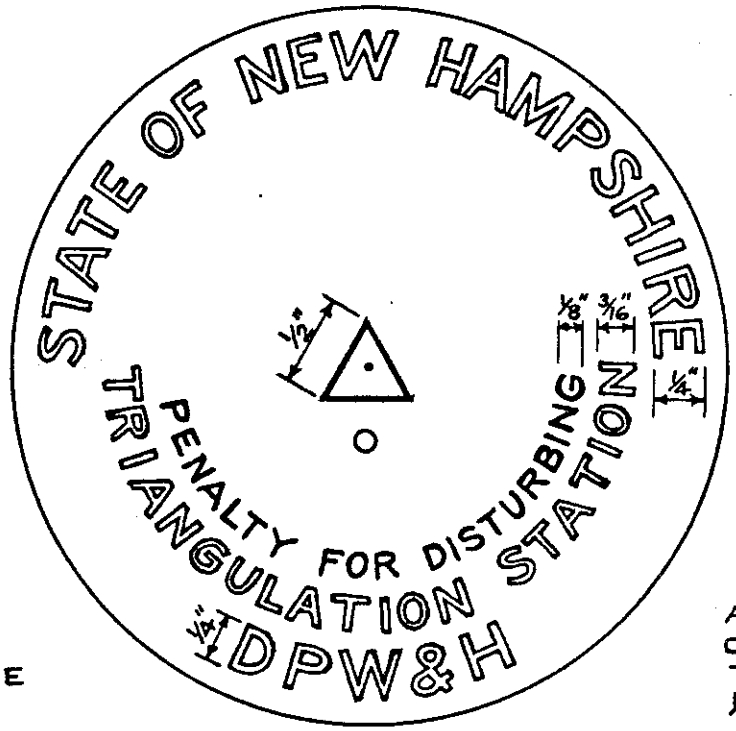
STEEL TAPE TEMPERATURE CORRECTIONS

Thermometer Reading °F	Temperature Correction	Thermometer Reading °F	Temperature Correction	Thermometer Reading °F	Temperature Correction
-10	-.050	28	-.026	66	-.001
- 9	-.050	29	-.025	67	-.001
- 8	-.049	30	-.025	68	.000
- 7	-.048	31	-.024	69	+.001
- 6	-.048	32	-.023	70	+.001
- 5	-.047	33	-.023	71	+.002
- 4	-.046	34	-.022	72	+.003
- 3	-.046	35	-.021	73	+.003
- 2	-.045	36	-.021	74	+.004
- 1	-.045	37	-.020	75	+.005
0	-.044	38	-.019	76	+.005
1	-.043	39	-.019	77	+.006
2	-.043	40	-.018	78	+.006
3	-.042	41	-.017	79	+.007
4	-.042	42	-.017	80	+.008
5	-.041	43	-.016	81	+.008
6	-.040	44	-.015	82	+.009
7	-.039	45	-.015	83	+.010
8	-.039	46	-.014	84	+.010
9	-.038	47	-.014	85	+.011
10	-.037	48	-.013	86	+.012
11	-.037	49	-.012	87	+.012
12	-.036	50	-.012	88	+.013
13	-.035	51	-.011	89	+.014
14	-.035	52	-.010	90	+.014
15	-.034	53	-.010	91	+.015
16	-.034	54	-.009	92	+.015
17	-.033	55	-.008	93	+.016
18	-.032	56	-.008	94	+.017
19	-.032	57	-.007	95	+.017
20	-.031	58	-.006	96	+.018
21	-.030	59	-.006	97	+.019
22	-.030	60	-.005	98	+.019
23	-.029	61	-.005	99	+.020
24	-.028	62	-.004	100	+.021
25	-.028	63	-.003	101	+.021
26	-.027	64	-.003	102	+.022
27	-.026	65	-.002	103	+.023

Temperature Correction Normal 68 Degrees. Tape Temperature Correction for each Degree 0.000645 per 100 Ft. based on the formula $C = 0.00000645\ (T-68)L$. Where; C = Correction in Ft., T = present temperature, in Degrees Fahrenheit, and L = a distance measured to nearest foot.

TABLE OF OFFSETS FROM TANGENT FOR CURVES FROM 0°15' to 6°00'

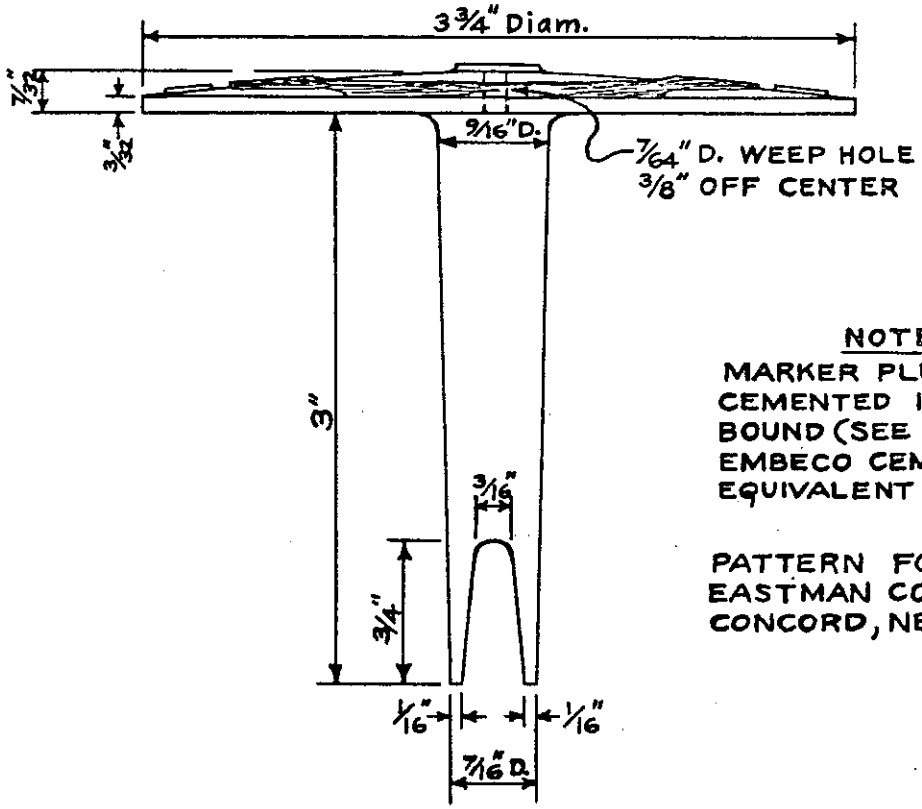
DEGREE	OFFSET IN FEET																
	25'	50'	75'	100'	150'	200'	250'	300'	350'	400'	450'	500'	600'	700'	800'	900'	1000'
0° 15'	0.0	0.1	0.1	0.2	0.5	0.9	1.4	2.0	2.7	3.5	4.4	5.5	7.9	10.7	14.0	17.7	21.8
0° 30'	0.0	0.1	0.3	0.4	1.0	1.8	2.7	4.0	5.4	7.0	8.8	10.9	15.7	21.4	28.0	35.4	43.7
0° 45'	0.0	0.2	0.4	0.7	1.5	2.6	4.1	5.9	8.0	10.5	13.3	16.4	23.6	32.1	42.0	53.2	65.7
1° 00'	0.1	0.2	0.5	0.8	2.0	3.5	5.5	7.9	10.7	14.0	17.7	21.9	31.5	42.9	56.1	71.1	87.9
1° 15'	0.1	0.3	0.6	1.1	2.5	4.4	6.8	9.8	13.4	17.5	22.1	27.4	39.4	53.8	70.4	89.2	110.4
1° 30'	0.1	0.3	0.7	1.3	3.0	5.2	8.2	11.8	16.1	21.0	26.6	32.9	47.4	64.7	84.7	107.5	133.2
1° 45'	0.1	0.4	0.9	1.5	3.4	6.1	9.6	13.8	18.8	24.5	31.1	38.4	55.5	75.7	99.2	126.1	156.5
2° 00'	0.1	0.4	1.0	1.8	3.9	7.0	10.9	15.8	21.5	28.1	35.6	44.0	63.5	86.8	114.0	145.0	180.2
2° 15'	0.1	0.5	1.1	2.0	4.4	7.9	12.3	17.7	24.2	31.6	40.1	49.6	71.7	98.1	128.9	164.3	204.6
2° 30'	0.1	0.6	1.2	2.2	4.9	8.7	13.7	19.7	26.9	35.2	44.6	55.2	79.9	109.5	144.2	184.1	229.7
2° 45'	0.2	0.6	1.4	2.4	5.4	9.6	15.1	21.7	29.6	39.5	49.2	60.9	88.3	121.1	159.7	204.4	255.7
3° 00'	0.2	0.7	1.5	2.6	5.9	10.5	16.4	23.7	32.4	42.4	53.8	66.6	96.7	132.9	175.6	225.5	282.7
3° 15'	0.2	0.7	1.6	2.8	6.4	11.4	17.8	25.7	35.1	46.0	57.3	72.3	105.2	144.9	191.9	247.0	311.0
3° 30'	0.2	0.8	1.7	3.1	6.9	12.3	19.2	27.7	37.8	49.6	61.3	78.2	113.9	157.2	208.8	269.6	340.9
3° 45'	0.2	0.8	1.8	3.3	7.4	13.1	20.6	29.7	40.6	53.3	67.8	84.1	122.7	169.8	226.1	293.1	372.6
4° 00'	0.2	0.9	2.0	3.5	7.9	14.0	22.0	31.8	43.4	56.9	72.5	90.1	131.9	182.7	244.2	318.0	406.7
4° 15'	0.2	0.9	2.1	3.7	8.4	14.9	23.4	33.8	46.2	60.7	77.3	96.1	140.8	195.9	263.0	344.3	443.8
4° 30'	0.3	1.0	2.2	3.9	8.9	15.8	24.8	35.8	49.0	64.5	82.2	102.3	150.2	209.6	282.6	372.5	484.9
4° 45'	0.3	1.0	2.3	4.2	9.4	16.7	26.2	37.9	51.9	68.2	87.1	108.5	159.8	221.0	303.4	403.0	532.1
5° 00'	0.3	1.1	2.5	4.4	9.9	17.6	27.6	40.0	54.7	72.1	92.0	114.8	169.6	238.6	325.3	436.4	586.0
5° 15'	0.3	1.2	2.6	4.6	10.4	18.5	29.0	42.0	57.6	75.9	97.1	121.2	179.1	254.0	348.9	473.8	653.7
5° 30'	0.3	1.2	2.7	4.8	10.9	19.4	30.4	44.1	60.5	79.8	102.2	127.8	190.1	270.1	374.8	516.7	748.8
5° 45'	0.3	1.3	2.8	5.0	11.4	20.3	31.9	46.2	63.5	83.8	107.4	134.5	200.8	287.1	402.1	571.8	—
6° 00'	0.3	1.3	3.0	5.3	11.9	21.2	33.3	48.3	66.4	87.8	112.6	141.3	211.9	303.1	433.1	634.8	—



SCALE : FULL SIZE

NOTE
ALL LETTERS AND CENTER TRIANGLE TO BE EMBOSSED 1/32" APPROXIMATELY.

TOP VIEW



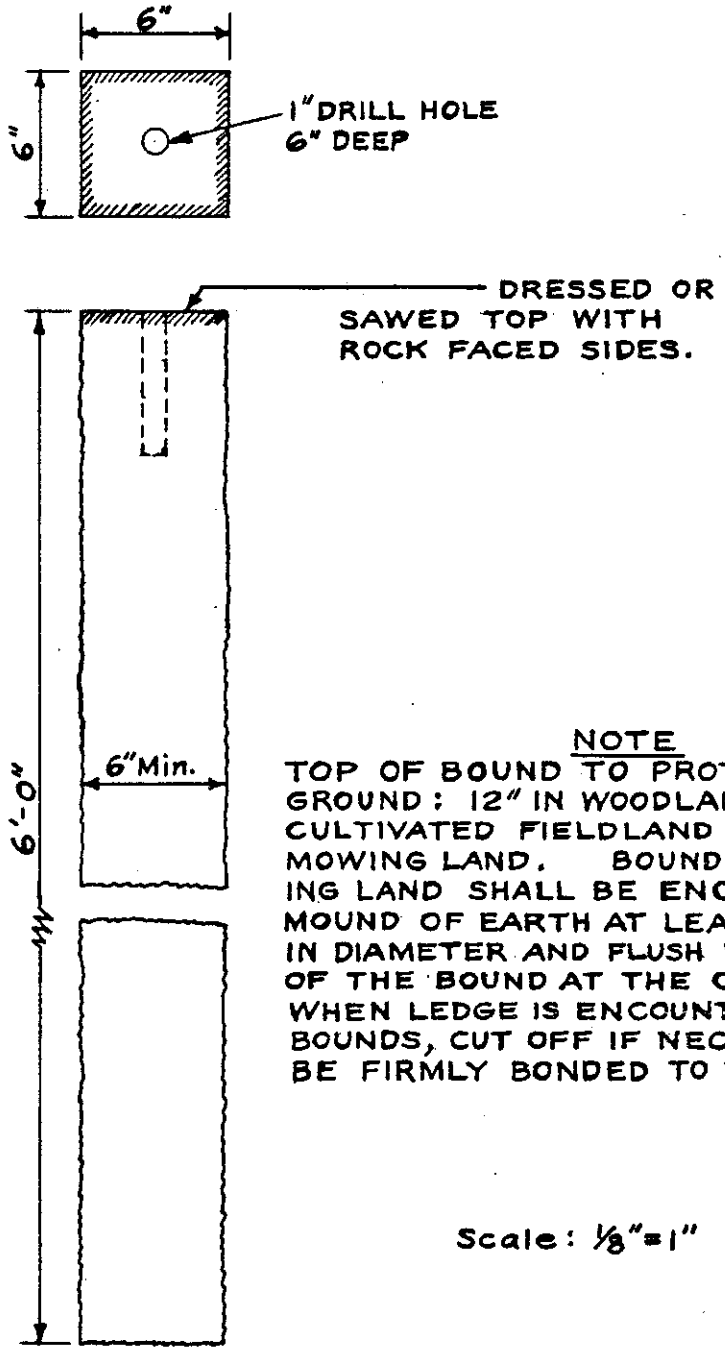
NOTE
MARKER PLUG TO BE CEMENTED INTO STONE BOUND (SEE FILE NO. 39116-D). EMBECO CEMENT OR EQUIVALENT TO BE USED.

PATTERN FOR PLUG AT EASTMAN CO. INC. FOUNDRY CONCORD, NEW HAMPSHIRE.

ELEVATION VIEW

E.H.R.

APPROVED OCT. 13, 1960 R G Brunel DESIGN ENGINEER	STATE OF NEW HAMPSHIRE DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS BRONZE MARKER PLUG	REV. DATE	STANDARD PLATE FILE NO. 39117-D



SPECIFICATION

STONE BOUND SHALL BE HARD AND DURABLE GRANITE AND SHALL BE FREE FROM SEAMS OR OTHER IMPERFECTIONS.

NOTE

TOP OF BOUND TO PROTRUDE ABOVE GROUND: 12" IN WOODLAND, 6" IN UNCULTIVATED FIELDLAND AND 4" IN MOWING LAND. BOUND SET IN MOWING LAND SHALL BE ENCIRCLED BY A MOUND OF EARTH AT LEAST 4 FEET IN DIAMETER AND FLUSH WITH THE TOP OF THE BOUND AT THE CENTER. WHEN LEDGE IS ENCOUNTERED, THE BOUNDS, CUT OFF IF NECESSARY, SHALL BE FIRMLY BONDED TO THE LEDGE.

Scale: 1/8"=1"

STATE OF NEW HAMPSHIRE
DEPT. OF PUBLIC WORKS AND HIGHWAYS

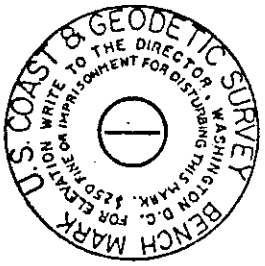
DETAIL OF STONE BOUND FOR PERMANENT MONUMENTS

APPROVED: R.A. Brunel DESIGN ENGINEER APRIL 6, 1960

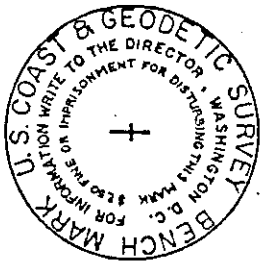
E.H.R.

File No. 39116-D

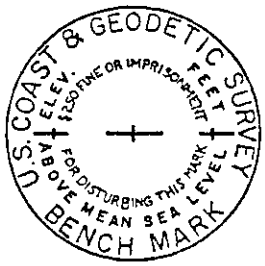
SURVEY MONUMENTS



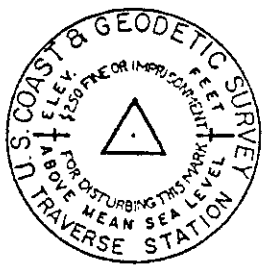
BENCH
(Old Type)



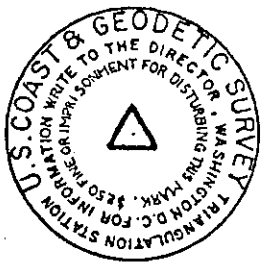
BENCH
(New Type)
Two Bench Marks Consolidated



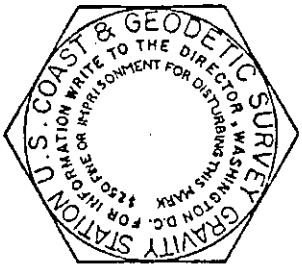
BENCH
(Old Type)



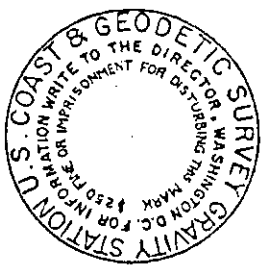
TRAVERSE



TRIANGULATION

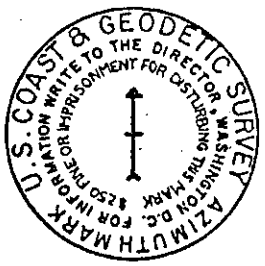


GRAVITY
(Old Type)

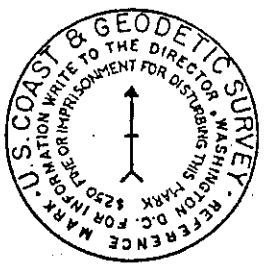


GRAVITY
(New Type)

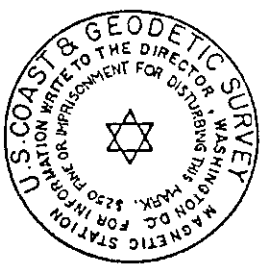
TOPOGRAPHIC



AZIMUTH



REFERENCE

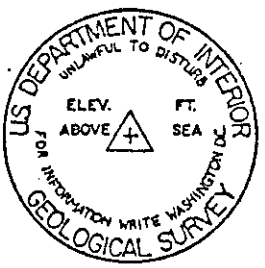


MAGNETIC

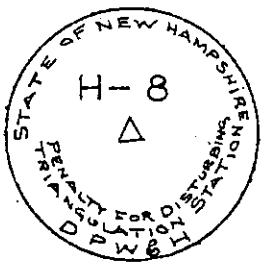
S.H.C.

BENCH

U.S.G.S.
(Old Type)



U.S.G.S.
(New Type)



TRIANGULATION

NOTE. The markers shown must be referenced to line by exact ties; all information shown on the plate must be given. Give a description of plate location: in ledge, boulder, concrete post, bridge abutment, etc. If marker is to be relocated due to construction, notify the Location Engineer in time for him to procure a new plate from the appropriate agency.

STANDARD ABBREVIATIONS

Azimuth	Az.
Average Water Level	A.W.L.
Back Traverse	B.Tr.
Bearing	Brg.
Bench Mark	B.M.
Bituminous Coated Corrugated Steel Pipe Arch	B.C.C.S.P.A.
Bituminous Coated Corrugated Steel Pipe	B.C.C.S.P.
Bituminous Coated Perforated Corrugated Steel Pipe	B.C.P.C.S.P.
Bottom of Bank	B.B.
Cast Iron Pipe	C.I.P.
Catch Basin	C.B.
Cement Lined Cast Iron Pipe	C.L.C.I.P.
Cemetery	Cem.
Center Line	C.L. or ℄
Concrete Bound	Conc.B.
Conduit	Cond.
Construction Center Line	C.C.L.
Controlled Access Right of Way	C.A.R.O.W.
Corner Fence Post	C.F.P.
Corrugated Aluminum Pipe	C.A.P.
Corrugated Steel Pipe	C.S.P.
County Line	Cty.L.
Curve to Spiral	C.S.
Degree of Curve	D.
Down Gradual	D.G.
Drive (label type)	Dr.
Drop Inlet	D.I.
Earth to Ledge	E.L.
Edge of Brook	E.Brk.
Edge of Pit	E.P.
Edge of River	E.R.
Edge of Work	E.W.
External Distance	E.
Extreme High Water	E.H.W.
Extreme Low Water	E.L.W.
Federal-aid Primary	F.A.P.
Federal-aid Secondary	F.A.S.
Fence (label type)	Fn.
Flow Line Elevation	F.L.
Fore Sight	F.S.
Gas Shut-Off	G.S.O.
Gravel	Grav.
Grid North	G.N.
Hand Level	H.L.
Header	Hdr.
Height of Instrument	H.I.
Horizontal Control Marker	H.C.M.
Hot Bituminous Paved Shoulder	H.B.P.S.

STANDARD ABBREVIATIONS

Hot Bituminous Pavement	H.B.P.
Invert Elevation	Inv.
Iron Pipe or Pin	I.P.
Ledge to Earth	L.E.
Length of Curve or Ledge	L.
Level Out	L.O.
Limited Access Right of Way	L.A.R.O.W.
Manhole (label type, sewer, telephone, etc.)	M.H.
Mean High Sea Level	M.H.W.
Mean Low Sea Level	M.L.W.
Mean Sea Level	M.S.L.
Mid-Point of Circular Curve	Mid.P.
Mortar Rubble Masonry	M.R.M.
Not Stripped	N.S.
Observed Magnetic Bearing	Mag.
Old Ground	O.G.
Old Stone Box	O.S.B.
Parking Lot	P.Lot.
Paved Gutter	P.G.
Paved Shoulder	P.S.
Perforated Asbestos-Cement Pipe	P.A.C.P.
Perforated Corrugated Aluminum Pipe	P.C.A.P.
Perforated Fiber Pipe Underdrain	P.F.P.U.
Point of Compound Curve	P.C.C.
Point of Curve	P.C.
Point of Intersection	P.I.
Point of Reverse Curve	P.R.C.
Point of Tangent	P.T.
Point on Curve	P.O.C.
Point on Sub-tangent	P.O.S.T.
Point on Tangent	P.O.T.
Portland Cement Concrete Pipe	P.C.C.P.
Project Marker	P.M.
Property Line	P.L.
Radius	R.
Railroad	R.R.
Railroad Crossing	R.R.X.
Reference Stake	R.S.
Reference Bound	R.B.
Reinforced Concrete Pipe	R.C.P.
Reinforced Concrete Pipe Underdrain	R.C.P.U.
Retaining Wall (label type)	R.W.
Right of Way	R.O.W.
Rip Rap	Rip.R.
Same Slope	S.S.
Sidewalk (label type)	S.W.
Sluiceway	Slu.

STANDARD ABBREVIATIONS

Spike	Spk.
Spike & Washer	S.&W.
Spiral Point of Intersection	S.P.I.
Spiral to Curve	S.C.
Spiral to Tangent	S.T.
Stake and Stones	S.&S.
State-aid Primary	S.A.P.
State-aid Secondary	S.A.S.
State Line	St.L.
Stone Bound	S.B.
Study or Survey Line	S.L.
Surface Treated Gravel	S.T.G.
Temporary Bench Mark	T.B.M.
Tangent to Spiral	T.S.
Top of Bank	T.B.
Town Line	T.L.
Traveled Way	T.W.
Traverse Line	Tr.L.
Turning Point	T.P.
Up Gradual	U.G.
Underdrain	U
United States Coastal & Geodetic Survey	U.S.C.&G.S.
United States Geological Survey	U.S.G.S.
Vitrified Clay Pipe	V.C.P.
Wall (label type)	W.
Water Gate	W.G.
Water Shut-Off	W.S.O.

STATE OF NEW HAMPSHIRE
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS

Electronic Computer Section
TRAVERSE COMPUTATIONS

* - Project _____ Project No. _____

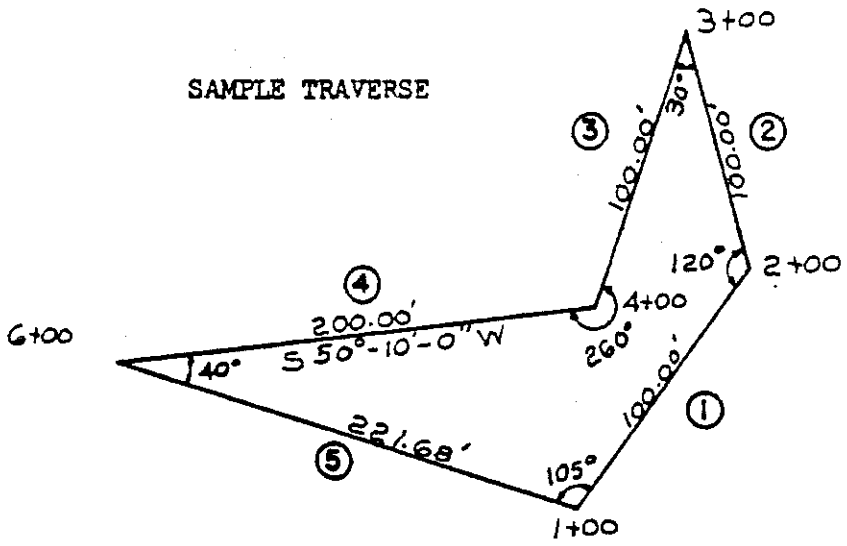
* Coordinates ☐ Assumed ☐ Tied To _____ Project No. Data from field books _____ _____ _____

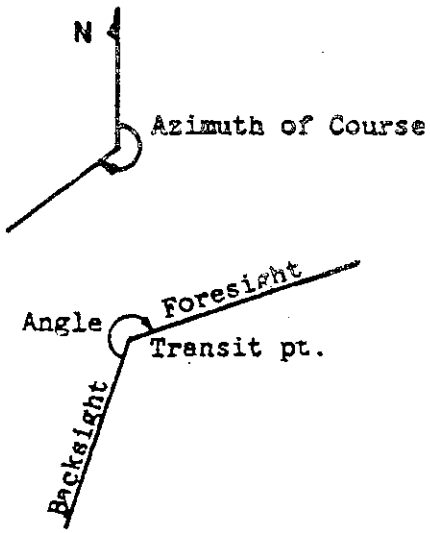
* ☐ Closed Traverse ☐ Open Traverse Submitted by _____ Date _____

* Remarks _____

* _____

SAMPLE TRAVERSE





Azimuth of Course No. 04 is 230° 10' 00.0"

STATION	Deg.	ANGLE	Sec.	COURSE NO.	DISTANCE
1+00.0	000	0	0.0	01	100.0
2+00.0	120	0	0.0	02	100.0
3+00.0	030	0	0.0	03	100.0
4+00.0	260	0	0.0	04	200.0
6+00.0	040	0	0.0	05	221.68
1+00.0	105	0	0.0	06	
+					

Starting Coordinates		Ending Coordinates	
Latitude	Departure	Latitude	Departure

The Azimuth of Course No. ☐☐ is ☐☐☐° ☐☐′ ☐☐.☐☐″

1 Station 9	11 Deg. 13 Angle 18 Sec. 21			Course No 23 24	26 Distance 34
	0,0,0	0,0	0,0,.,0	01	
				02	
				03	
				04	
				05	
				06	
				07	
				08	
				09	
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				29	
				30	

E.C.T. 12/2/65

Recorded by _____

Checked by

STATE OF NEW HAMPSHIRE
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
ELECTRONIC COMPUTER SECTION

TRAVERSE COMPUTATION
Schematic Sketch Sheet

PROJECT_____ PROJECT NO._____ FED.NO._____ DATE_____

1. PROVIDE THE FOLLOWING INFORMATION:

A. P.I. or P.O.T. Station
B. Measured Angle (clockwise)
C. Tangent Distance
D. Observed Magnetic Bearing Used.
E. Computed Bearings.

RECORDED BY_____ DATE_____
CHECKED BY_____ DATE_____